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On MDA-SOA based Intercloud Interoperability framework

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Abstract

Cloud computing has been one of the latest technologies which assures reliable delivery of on-demand computing services over the Internet. Cloud service providers have established geographically distributed datacenters and computing resources, which are available online as service. The clouds operated by different service providers working together in collaboration can open up lots more spaces for innovative scenarios with huge amount of resources provisioning on demand. However, current cloud systems do not support intercloud interoperability. This paper is thus motivated to address Intercloud Interoperability by analyzing different methodologies that have been applied to resolve various scenarios of interoperability. Model Driven Architecture (MDA) and Service Oriented Architecture (SOA) method have been used to address interoperability in various scenarios, which also opens up spaces to address intercloud interoperability by making use of these well accepted methodologies. The focus of this document is to show Intercloud Interoperability can be supported through a Model Driven approach and Service Oriented systems. Moreover, the current state of the art in Intercloud, concept and benefits of MDA and SOA are discussed in the paper. At the same time this paper also proposes a generic architecture for MDA-SOA based framework, which can be useful for developing applications which will require intercloud interoperability. The paper justifies the usability of the framework by a use-case scenario for dynamic workload migration among heterogeneous clouds.

Keywords: Cloud Computing, Intercloud, Cloud Interoperability, Model Driven Architecture (MDA), Service Oriented Architecture (SOA).

1. Introduction

Cloud computing as a recent computation paradigm has been developing very quickly. A cloud delivers on-demand services ranging from software to platform or infrastructure services (SaaS, PaaS, and IaaS) over the internet. To date cloud environments include hundreds of individual, heterogeneous, private/hybrid clouds with finite physical resources, but it is predicted in the near future expansion of the application scope of cloud services requires cooperation between the clouds. This interworking mechanism between clouds is called “Intercloud”. Interoperability between clouds can provide:

- Better Quality of Service such as scalability and better reliability, service availability and performance than a single cloud system.
- Avoidance of vendor lock-in by using multiple clouds and freely migrating workload among them.
- Enabling inter-cloud Resource Sharing and enabling cloud users to use combined services from different service providers. These widely distributed resources can also reside in data centers worldwide.
- Reducing power consumption and/or labor costs due to delivering services from various locations.
- Currently, there are no implicit interoperability standards for heterogeneous cloud computing architectures to promote Intercloud interoperability. Different cloud computing systems from various companies and even the government are usually not interoperable.

Based on literature review, Service Oriented Architecture (SOA) method can considerably improve the cloud computing environment to provide the required service models with agility and scalability [1]. Additionally, according to literature, combination of Model Driven approach from Object Management Group (OMG) and SOA methodology can be exploited to perform analysis, design and implementation of enterprise integration and enhanced interoperability. According to the research focused on this paper, developing a novel

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framework based on Model Driven Architecture (MDA) and SOA approaches, can improve Intercloud Interoperability. Additionally, this paper also discusses the concept and state-of-the-art in Intercloud Interoperability. In order to have a better understanding of MDA and SOA technologies, an introduction to MDA Models (CIM, PIM, and PSM), model transformations concept and languages, metamodel concept are included. Furthermore, this document includes basic concept of SOA method and description of core standards of SOA approach to provide interoperability. Finally a scenario is described in order to define the case study for our Intercloud Interoperability Framework which exploits FI-WARE platform that has a cloud hosting generic implementations. The FI-WARE[1] cloud offers Generic Enablers (GEs)[2] with the aim of establishing a modern cloud hosting infrastructure to develop and manage Future Internet applications and services. One of these GEs is JobScheduler GE. Our framework is according to JobScheduler GE to dispatch different tasks dynamically over multiple computing resources from other cloud providers.

2. Cloud Computing

The concept of "Cloud" is not a new one and it has been used in several fields such as ATM networks in 1990s. The term of "Cloud" is used to describe the networks that incorporate various technologies, without the user knowing it.

In 1997, as the first academic definition, Chellapa clarified cloud computing as "a computing paradigm where the boundaries of computing will be determined rationale rather than technical" [2].

The National Institute of Standards and Technology (NIST) proposed a cloud computing definition as follows: "Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models" [3][4].

Fig. 1. shows the framework introduced by NIST to define cloud computing [5].

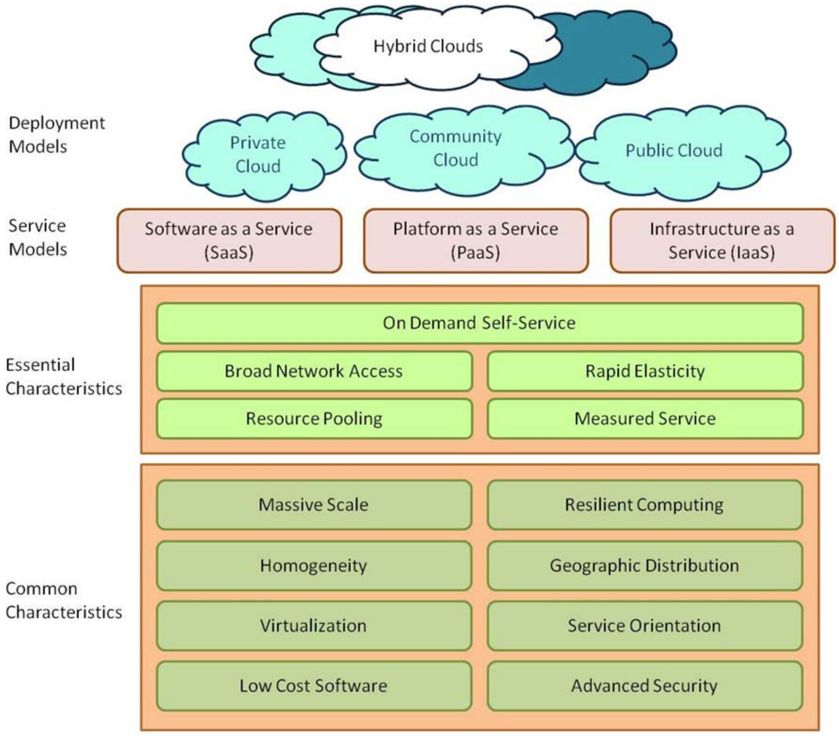

Fig. 1. Cloud Computing Definition [5].

[1] http://www.fi-ware.eu/
[2] http://forge.fi-ware.eu/plugins/mediawiki/wiki/fiware/index.php/FI-WARE_Cloud_Hosting

According to the different perspectives of various corporations such as; academicians, architects, consumers, developers, engineers and managers, there are several definitions for cloud computing [6]. This document adopted the cloud definition from Bernstein et al [7] article:

“Cloud Computing is a datacenter which:

- Implements a pool of computing resources and services which are shared amongst subscribers.
- Charges for resources and services using an “as used” metered and/or capacity based model.
- Are usually geographically distributed, in a manner which is transparent to the subscriber (unless they explicitly ask for visibility of that).
- Are automated in that the provisioning and configuration (and de-configuration and unprovisioning) of resources and services occur on the “self service”, usually programmatic request of the subscriber, occur in an automated way with no human operator assistance, and are delivered in one or two orders of seconds.
- Resources and services are delivered virtually, that is, although they may appear to be physical (servers, disks, network segments, etc) they are actually virtual implementations of those on an underlying physical infrastructure which the subscriber never sees.
- The physical infrastructure changes rarely. The virtually delivered resources and services are changing constantly.”
- According to the NIST [4] definition, cloud computing specifies three delivery models to provide various services such as Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS):
- The IaaS vendors provide a scalable, secure, and accessible infrastructure over the Internet [8]. Amazon's EC2 [9], Windows Azure Virtual Machines [10], and Rackspace Cloud [11] are some popular available IaaS.
- Fundamentally, PaaS provides a high level of abstraction to allow developers to focus on building higher level applications. Software developers can provide a custom developed application without bothering customers with managing and maintaining the infrastructure. Google Compute Engine [12], AWS Elastic Beanstalk [13] and Microsoft Azure are popular PaaS examples.
- *SaaS* is a cloud computing layer where users access applications running on a cloud infrastructure and offered on a platform on-demand [6][4]. Usually the users are able to run these applications using a client interface, like a web-browser. Practically, all of the underlying implementation and deployment is abstracted from the SaaS clients and only a specific set of configuration controls are accessible. Furthermore, the relevant data of SaaS applications is transparently placed in the cloud infrastructure. Google Apps [14], Salesforce [15], SuccessFactors [15] are popular SaaS examples.

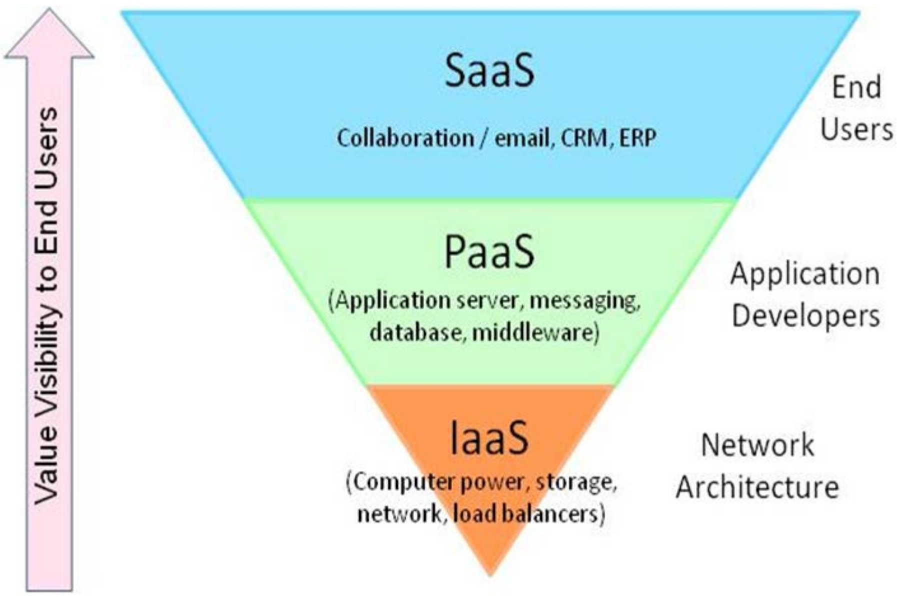

Fig. 2. Cloud Computing Pyramid.

Each level of service models adds additional functionality and provides required services for different kind of users from network architectures to end users (shown in Fig. 2.). Vaquero and colleagues introduced a flowchart (Fig. 3.) to illustrate the different actors and service delivery layers in Cloud Computing.

Zhang and colleagues [16] proposed a four layered architecture covering the three level of service model in cloud computing. As shown in Fig 4., the architecture includes the hardware/datacenter layer, the infrastructure layer, the platform layer and the application layer.

- The *hardware layer* is in charge of the physical resources available in the cloud, such as physical servers, routers, power and cooling systems. The hardware layer is normally implemented in the datacenters.
- The *infrastructure layer*, known as the *virtualization layer* is a crucial part of cloud computing. Its main responsibility is providing a pool of storage and computing resources by logical partitioning of the physical resources using virtualization technologies like Xen [17], KVM [18] and VMware [19].
- The *platform layer* is made up of operating systems and application frameworks to optimize running applications in VM containers.
- The *application layer* includes the cloud applications that can trigger the auto-scaling feature to achieve better performance, availability and lower operating cost.

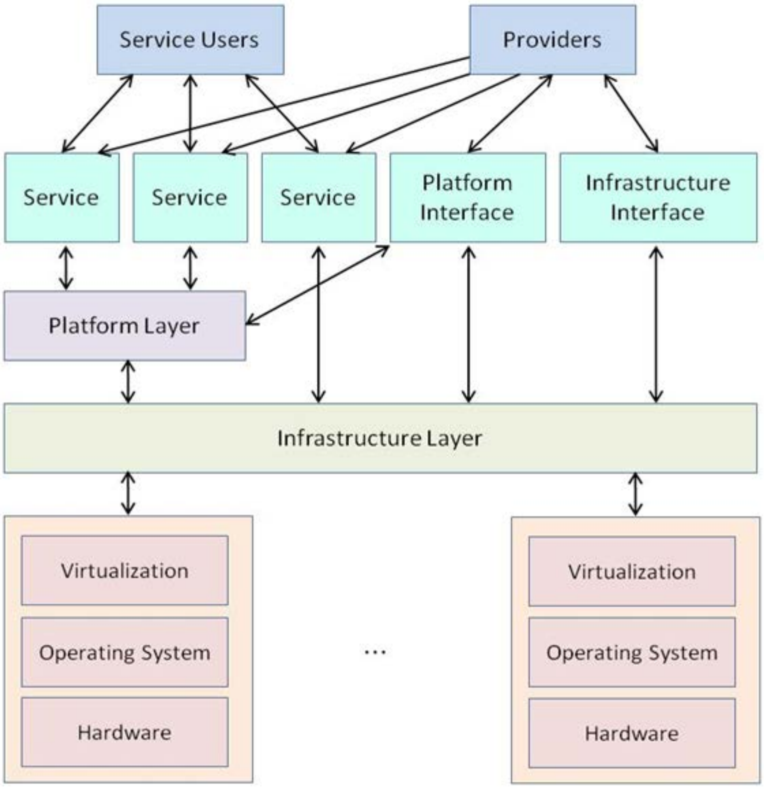

Fig. 3. Overview of actors and layers in Cloud Computing [80].

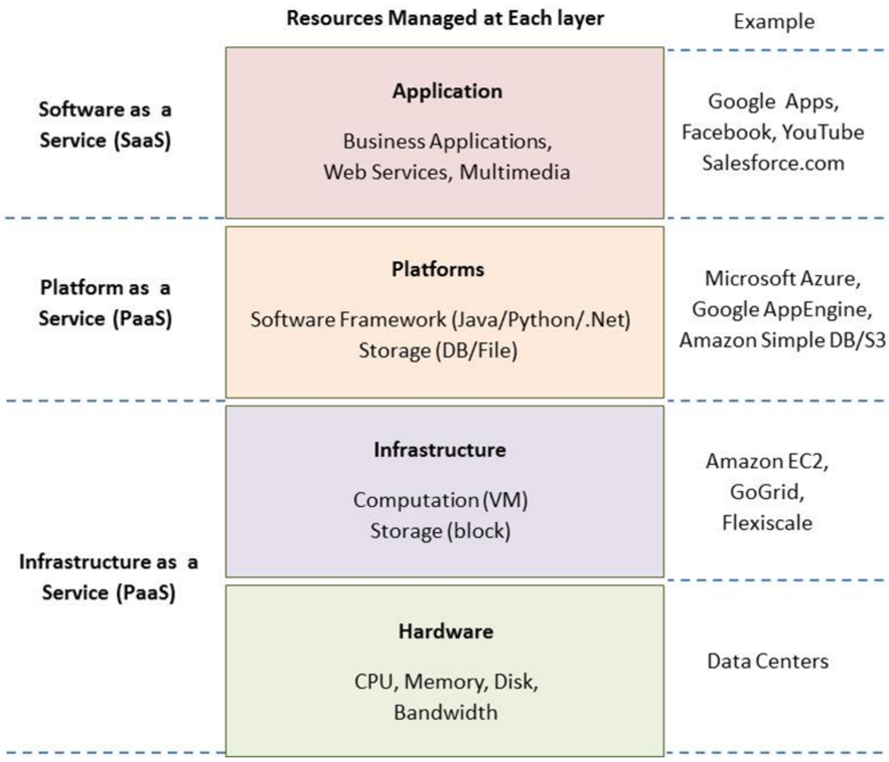

Fig. 4. Cloud computing architecture [16].

There are four generic types for cloud computing infrastructure deployment (shown in Fig. 5.): public cloud, private cloud, community cloud and hybrid cloud [20][6][4][5][21]. The architecture, the datacenter's location, and the requirements of cloud customers determine different deployment strategies [22].

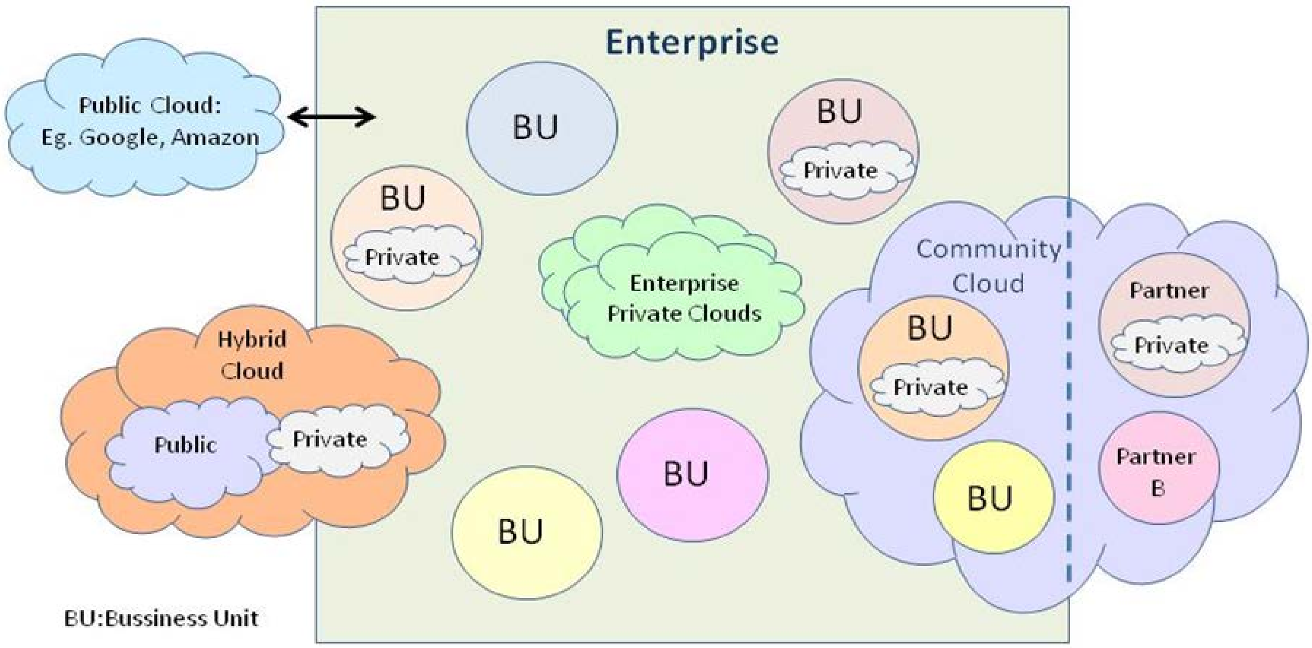

Fig. 5. Deployment models.

2.1. Intercloud Interoperability

Currently, cloud computing is an emerging computation paradigm in information technology and networking. Although Cloud Computing shared services has been increasingly utilized by diverse users, the research on Cloud Computing is still at an early stage. There are many existing cloud challenges that have not been fully addressed in addition to the new emerging issues introduced by enterprise applications. One of the existence challenges is the Intercloud Interoperability issue.

Intercloud became popular in early 2009 [23][7][24]. The Intercloud concept is based on the fact that each single cloud has limited computing resources in a restricted geographic area. Intercloud addresses the interoperability between various cloud computing instantiations where each cloud would use computing resources of other clouds. Cloud Computing environments need to be interoperable in order to reduce scaling/producing cost within the development of the components. Cloud costumers should be able to migrate in and out of the cloud and switch between providers based on their needs, without a lock-in which restricts customers from selecting an alternative provider. Furthermore, cloud providers should be able to interoperate among themselves to find an alternative cloud provider to give better services. The present Intercloud network merely connects different cloud systems and each cloud provider has its own way on how cloud applications/customers interact with the cloud. Feldhaus [25] summarized the current challenges in Cloud Interoperability as follow:

- Several different Cloud Standards from different parties are available.
- Existing Open Grid Forum (OGF) standards not or only partly ready for the cloud.
- A consistent OGF Cloud Portfolio is needed.
- Strategies for combining different Cloud Standards / APIs are needed.
- Existing implementations of Cloud APIs need to get interoperable.
- Combined Interoperability Verification Suites need to be developed.
- It is essential to discuss on issues related to specifications and implementation.

Currently different organizations, such as IEEE, are working on developing essential standards and appropriate APIs for Intercloud Interoperability. The future Intercloud network will expand the required functions to prepare collaboration among cloud services. Grozev & Buyya summarized their studies and classified 20 major Intercloud developments including both academic and industry projects [26]. According to their studies, Intercloud is classified as (Error! Reference source not found.Fig. 6.):

- *Volunteer federation*: when there is voluntarily collaboration between cloud providers that is often feasible for governmental clouds or private cloud portfolios.
- *Independent:* when an application or its broker independently from the cloud providers (both governmentally and private clouds) exploit multiple clouds.

Volunteer federation is classified in two architectural categories (Fig. 7) [26]:

- *Centralised*: there is a central entity in this architecture for intercloud to perform or facilitate resource allocation.
- *Peer-to-Peer*: *in this architecture, each cloud cooperates with the others directly*.

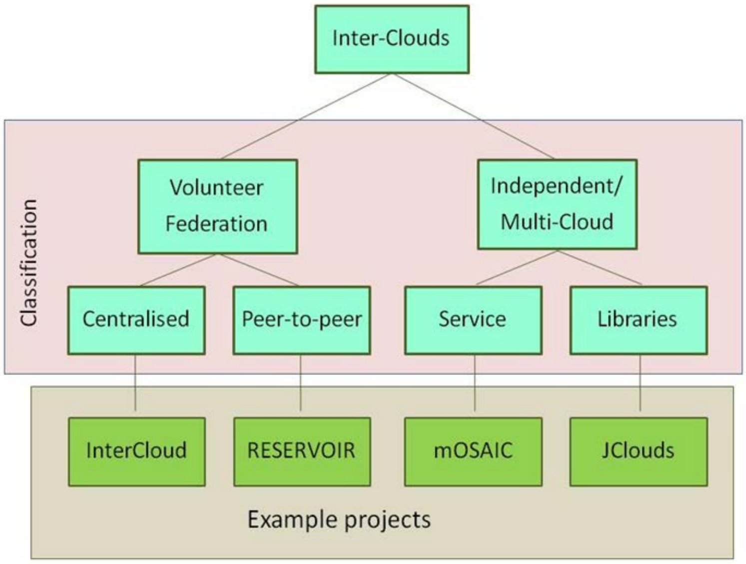

Fig. 6. Architectural classification of intercloud [26].

Furthermore, the *Independent Intercloud* development is classified in two architectural categories (Fig. 7.) [26]:

- *Services:* a service hosted externally or in-house by the users provides the application. Often, broker components are part of this type of services, and an SLA or a set of provisioning rules for application developers are defined by application and the service executes in the background according to the predefined attributes.
- *Libraries:* usually custom application brokers are required to provide and schedule application components directly across clouds. These approaches exploit intercloud libraries which facilitate utilizing multiple clouds uniformly.

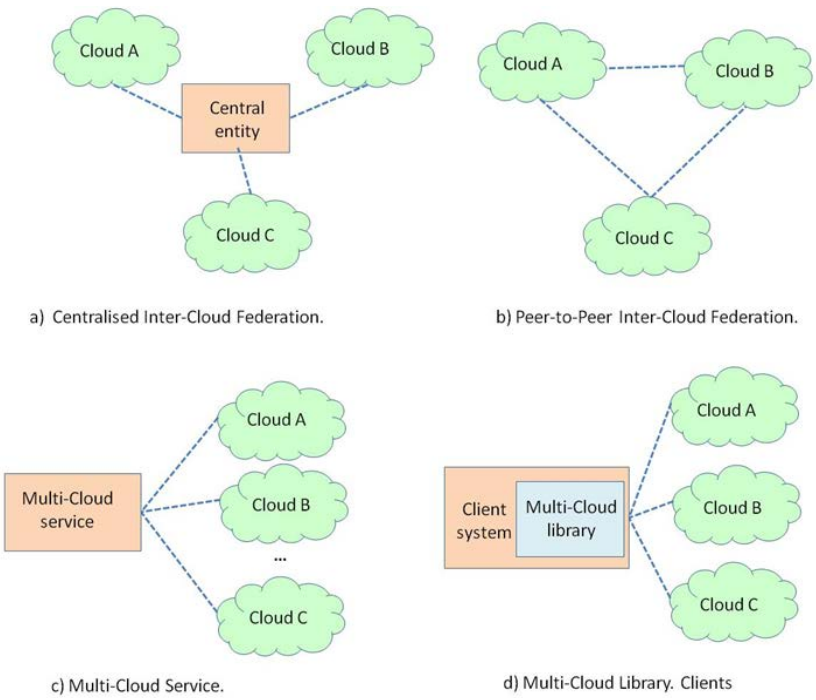

Fig. 7. Intercloud developments' architecture.

Dillon and colleagues [27] summarized some key intentions to solve the interoperability issue in the Cloud environments:

- *Intermediary Layer*: Providing an intermediary layer between cloud users and cloud computing resources (e.g.VM) may help improving cloud systems' interoperability. For instance, an abstraction layer can be developed at a higher level to provide a single resource usage model, user authentication model and API to support heterogeneous cloud providers.
- *Standard:* Standardization can be a solution to address the interoperability problem. The consensus between existing cloud providers, such as Amazon, Microsoft, or Google, is a big problem that makes standardization process very intricate.
- *Open API:* Open cloud API can define a set of clear and simple web services interfaces, to allow consumers to create and administrate cloud resources, including compute, storage, and networking components in a unified way.
- *SaaS and PaaS Interoperability*: Cloud providers mostly focused on IaaS interoperability problems, and few studies have highlighted interoperability issues in the other service deployment models.

Bernstein and colleagues [7] defined "Intercloud vision" shown in Fig. 8. to depict that various services from heterogeneous cloud systems are interoperable. Reference topology in Fig. 9. shows of how clouds interact in an InterMany of standards from current Internet networks are appropriate standards to reuse in Intercloud.

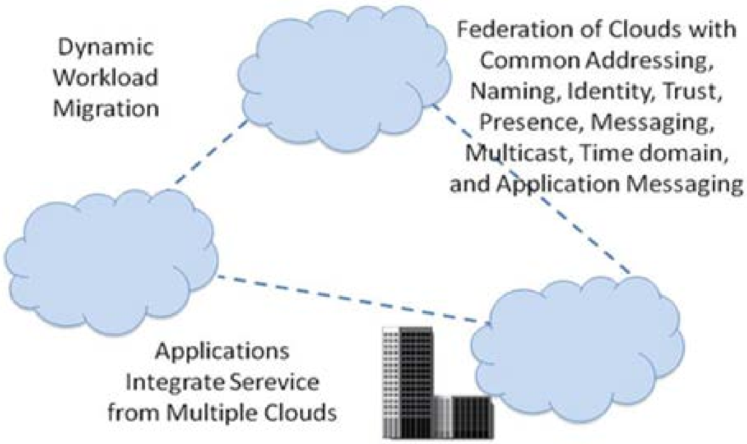

Fig. 8. The Intercloud Vision [7].

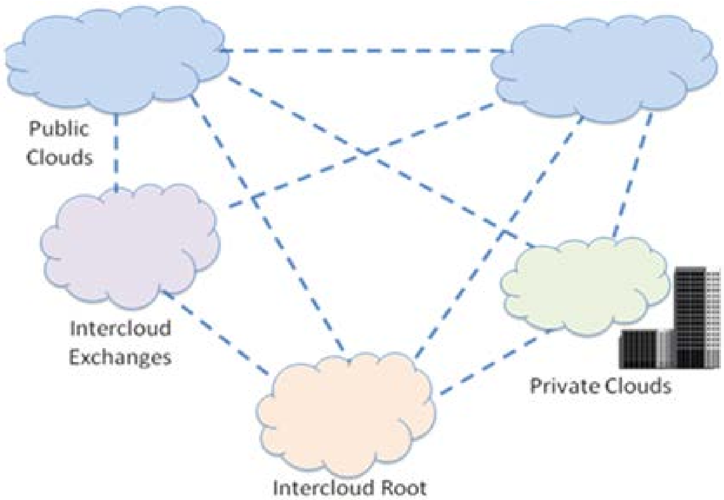

Fig. 9. Reference Intercloud Topology [79].

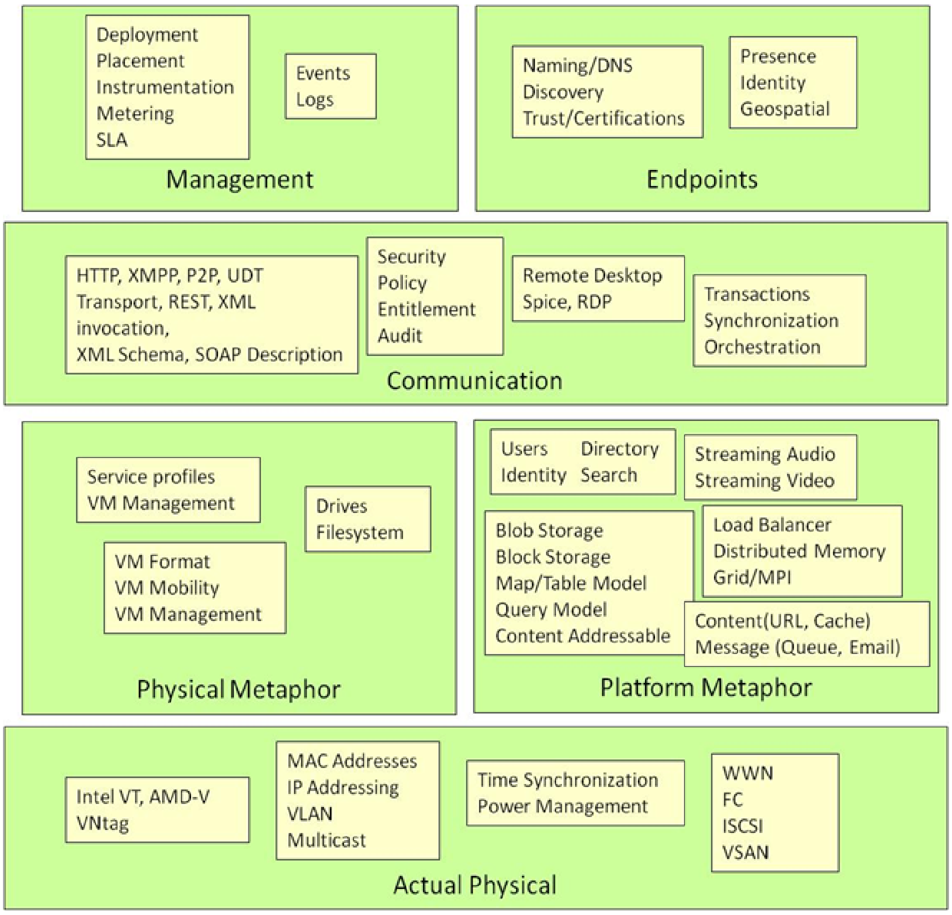

Fig. 10. An Architecture for Intercloud Standards [7].

Parameswaran and Chaddha [24] explained and examined two approaches in order to provide Intercloud standards and interoperability view:

Approach 1: Unified Cloud Interface/Cloud Broker and approach.

Approach 2: Enterprise Cloud Orchestration Platform /Orchestration layer.

Recently, the IEEE P2302 group [28] has been focusing on cloud-to-cloud interface standards for Intercloud Interoperability and Federation. Celesti in 2010 [29] proposed a three-phase (discovery, match-making, and authentication) cross-cloud federation model. This model represents an architectural solution (with some restrictions) to provide interoperability. In July 2009 in Japan, the Global Inter-Cloud Technology Forum (GICTF) published Intercloud Protocol [30] and Resource Data Model [31] to recognize the operational requirements of Intercloud systems and describe a peer-to-peer intercloud interface. However, it has been claimed in [32] Point to Point protocols are not appropriate for Intercloud Protocols and accordingly many-to-many mechanisms including Messaging and Presence Protocol (XMPP) for transport, and Semantic Web techniques such as Resource Description Framework (RDF) as a way to specify resources have been proposed. Bernstein and colleagues [32] used an XMPP Java API for a Cloud Service. Celesti also selected XML based technologies like XMPP to address interoperability issues [29]. Bernstein and colleagues [7] collected protocols, standards, formats, and common mechanisms as a beneficial architecture to implement Intercloud interoperability (Fig. 10.).

The Intercloud network scenario is still in an early stage. It needs more research work to provide sufficient functions to enable collaboration between cloud services. We are planning to present a framework to develop Intercloud Interoperability using two key technologies, MDA and SOA, described in following sections.

3. The Model Driven Architecture (MDA) Approach

The Object Management Group (OMG) announced the Model Driven Architecture (MDA) initiative as a software development approach to system-specification and interoperability based on the use of formal models [33]. MDA focuses on the development of models rather than detailed, platform-specific code which can be generated when needed. Instead of requiring developers to define every detail of a system's implementation using a programming language, it lets them model what functionality is needed and what overall architecture the system should have.

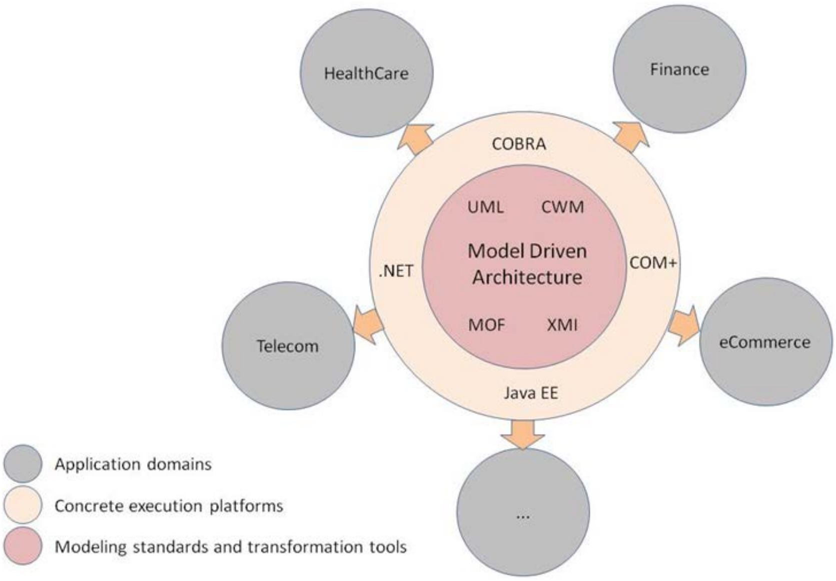

Fig. 11. The Model Driven Architecture [34].

The MDA approach gives the facility to understand complex and real-world systems while providing an abstraction of the physical system as shown in Fig. 11. [34]. This abstract view of the system is represented through the OMG's modeling standards including the Unified Modeling Language (UML) [35], Meta-Object Facility (MOF) [36], Common Warehouse Metamodel (CWM) [37] ,and XML Metadata Interchange (XMI) [38] which facilitates automatic generation of an XML-based document for a model according to its MOF definition.

MDA specifies three level of modeling abstractions: Computation Independent Model (CIM), Platform Independent Model (PIM) and Platform Specific Model (PSM) (Fig. 12.).

The *Computational Independent Model* (CIM) represents what the business actually does or wants to do in future, but hides all information technology related specifications to remain independent of how that system will be implemented. CIM is independent from the use of the system as a computer system, and excludes any implementation details [39]. In other words, this model could be viewed as a contractual element that acts as a reference to check if client requirements have been correctly fulfilled.

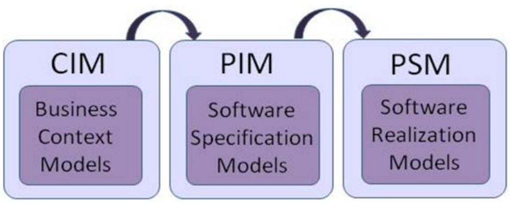

Fig. 12. Model Driven Architectures levels.

Ideally, software application design should be appropriate for all type of execution platforms (different operating systems, hardware, network protocols, programming languages, etc.) To achieve this Platform Independent Model (PIM) has been defined which provides a formal definition of the functionality of software system without addressing any specific operating platform. A platform-independent modeling language, such as UML, is used to design PIM model. The PIM model defines data, dependencies and architectural realizations. The model elements should provide enough information to make accordant code generation possible in next step. Based on platform independent model,

Platform specific model (PSM) provides the details to specify how the system uses a particular type of platform. In other words, PSM intends to ease generating corresponding code from the PIM that fits the operating platform [34]. The PIM model describes the system independent of XML, WSDL, SOAP, UDDI, Java, and other implementation technologies. The model-to-model and model-to-code transformations process would be accomplished using transformation tools that generate XML, WSDL, SOAP, UDDI, and the technology-specific artifacts and finally the implementation code from the design input [40].

Transformation techniques play a key role in making Model Driven approach successful. Transformations can be categorized based on the type of source and destination they operate on. At top level, model transformation approaches can be identified as *model-to-code* transformations or *model-to-model* transformations. Refer [41] for details on classification of MDA transformations. Various *transformation languages* and tool suites have been developed, such as QVT (Query/View/Transformation) [42][43][44], ATL (ATLAS Transformation Language) [45], GReAT (Graph Rewrite And Transformation language) [46][47][48], JTL (Janus Transformation Language) [49][50], Model-to-Model (M2M) [51], and MOLA: (MOdel transformation Language) [52][53][54].

4. The Service Oriented Architecture (SOA) Approach

Service Oriented Architecture (SOA) is a new architectural style to develop applications through services. It is defined as a collection of independent services which communicate with each other. The communication can include a simple data passing or two or more services coordinating the same activity. The connection for exchanging request and subsequent response messages between service customer and provider are specified in an understandable way to both the service consumer and provider. SOA is a new paradigm for solution architects to facilitate developing new value-added solutions by incorporating different solution artifacts such as business processes, services, packaged applications, and manageable attributes all over their lifecycle [55].

SOA defines an interaction model between three main functional units, shown in Fig. 13., in which the service consumer identifies adequate service via communication with the service provider through searching registry [56]. Practically, SOA contains six entities in its conceptual model, described as follow [56]:

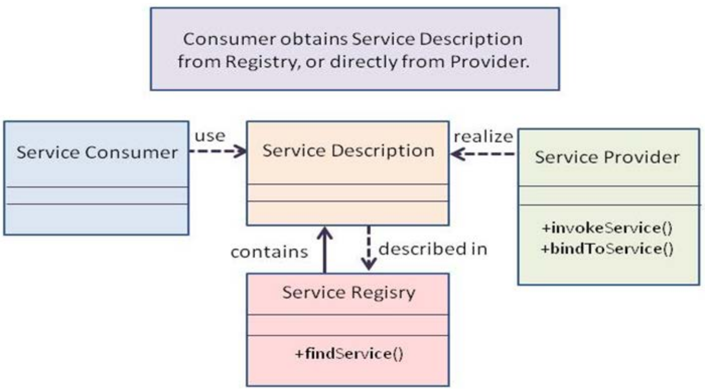

Fig. 13. Service Oriented Architecture Conceptual Model [56].

- *Service Consumer*: It is the entity that requests a service to execute a demanded function. If consumer knows the location of the service, it can communicate directly with the service provider, otherwise, it can detect the service location through the registry.
- *Service Provider*: It is an addressable entity of network that receives and executes the requests of consumers. It can provide the determined service description and the implement the service.

- *Service Registry*: It is a directory for available services which can be exploited through network. Service Registry should be able to publish and save service descriptions from providers and deliver the descriptions to the interested service consumers.
- *Service Contract*: It is a description that explicitly defines how the service consumer and provider should communicate. It includes information about the format of request-response message, the conditions in which the service should be executed, and quality aspects of the service.
- *Service Proxy*: It is an optional entity that facilitates the interaction between service provider and consumer through providing an API created in the local language of the consumer.
- *Service Lease*: It specifies and maintains the relationships between service consumer and provider. It defines the executive well-defined binding timeframes for the services that is managed by registry. It provides loose coupling between service provider and consumer as well as maintenance of state information for the service.

5. Interoperability via MDA and SOA

The interoperability between applications and services is inherent to the system design using MDA approach because MDA supports defining services, facilities, and applications through platform-independent model (PIM). Transforming the PIM to the PSM and then generating the code is based on the links provided between models. These links are specified by the metamodels' mappings (can also be linked with meta-models to add semantics) which allow platform specific and independent implementations to interoperate. Interoperability between two applications is provided by the mappings via the relevant metamodels of models. [57] and [58] have explored various dimensions of interoperability by making use of MDA and SOA. At the same time in the domain of the problem being addressed by this paper state of art on various transformation languages viz. ATL (ATLAS Transformation Language) [45], Model-to-Model (M2M) [51], and MOLA: (MOdel transformation Language) [54] provide a solid background to use MDA to achieve interoperability.

SOA inherits the ability of a service to be invoked by any potential service consumer and are connected using standard, dependency reducing decoupled message based methods. This methodology guarantees that services are coarse-grained reusable components that expose their functionality through a well-defined interface, systems can be built as a composition of services and evolve through the addition of new services. So, SOA methodology supports and promotes interoperable system designs. [59] presents a paradigm of cloud-marketplace ecosystem, making use of SOA to achieve collaborative marketplace architecture for the domain of e-procurement. At the same time oriented architecture Modeling Language (SoaML) offer several benefits such as [60] allowing service interoperability at the model level. A key issue for enabling interoperability is to come to an agreement about which services can be provided by whom and which can be consumed by whom in a network of service. Han at al. in [61] discusses how the OMG standards Business Motivation Model (BMM) [62] combined with SoaML can support Organizational Interoperability by enabling a community or organization to work together using SOA services at a higher level of abstraction. It also addresses service interaction concerns at the architectural levels by using architecture as the bridge between business requirements and automated IT solutions;

5.1 Current MDA, SOA based solutions for Cloud Computing

Recently, SOA and MDA approaches are increasingly exploited to develop different frameworks to alleviate several problems such as interoperability in enterprises [63][64][65][66][67][68][69]. Xu et al. claimed service interoperability is feasible using a model driven paradigm with service oriented systems [68]. Kim [69] specified main advantages to integrate a service-oriented modeling architecture with MDA:

- The clear organization of models and information based on the stereotypes derived from the SOA and Select Perspective as development process.
- The productivity, quality and impact analysis benefits of the use of MDA with its emphasis on automation, transformation and synchronization.

Cloud providers, mainly cloud Software-as-a-Service (SaaS), can use the advantages of MDA approach to develop the software applications. The interoperability between applications and services is the characteristic of a system designed based on MDA approach. Table 1 summarizes current research work on MDA-based solutions for Cloud Computing. Beside MDA approach, SOA method is a recent methodology which has significantly influenced IT architectures. SOA is fundamentally an architecture framework that can immensely help cloud computing architecture to provide the required services model with agility and scalability [1]. Additionally SOA promised interoperability between applications by put up application systems as group of published services [70]. Dillon and colleagues [27] described several ways that SOA can help implementing cloud services, such as Service Description for Cloud Services, Service Discovery for Cloud Services, Service Composition for Cloud Service, and Service Management for Cloud Service.

Considering the high-level definition of cloud and SOA, Infosys [1] presented how SOA and cloud overlap (Fig. 14.).

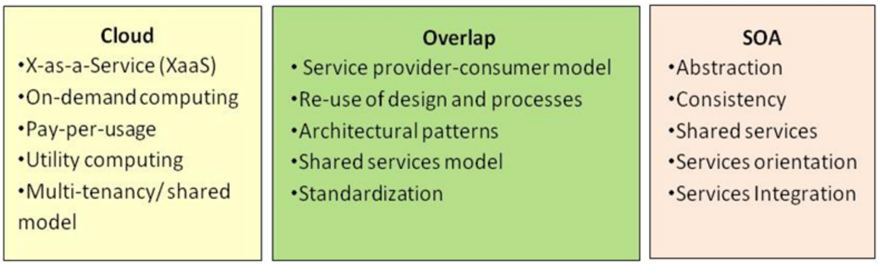

Fig. 14. Cloud and SOA overlap in several architectural aspects [1].

Table 1 also shows the current research work on SOA-based solutions for Cloud Computing. In addition to leverage MDA or SOA based solutions separately to develop Cloud Computing, it is possible to merge SOA, and MDA in progress of optimal solutions for Cloud Computing (e.g Sharma's research work [71]). We are planning to exploit MDA-based SOA method to get the benefits of these technologies in implementing a novel framework for Intercloud Interoperability.

Table 1. State-of-the-art for MDA-based, and SOA-based solutions of Cloud Computing.

	Year	Title	Area	What had been done?
[72]	2011	Cloud SaaS and Model Driven Architecture.	MDA-Cloud	Incorporating MDA reduces the impact of applying software technological advancements on software applications and it augments the rigor, durability and reusability of the cloud services. In this paper, MDA approach was deployed to develop cloud SaaS.
[73]	2011	A Model-Driven Approach to Cloud SaaS Interoperability	MDA-Cloud	This paper introduced an MDA-based approach to provide interoperability among the software services in the cloud.
[74]	2011	Enhancing Cloud SaaS Development With Model Driven Architecture	MDA-Cloud	In order to have robust, flexible and agile software solutions for advanced cloud software applications, this paper studied the MDA approach to develop software systems
[1]	2011	Connecting the dots : Cloud and SOA	SOA-Cloud	Infosys released a whitepaper in 2011 to present the overlap between SOA and Cloud Computing and explain how SOA has being connected and enhanced cloud.
[75]	2012	SoaML and UPIA Model Integration for Secure Distributed SOA Clouds	SoaML-Cloud	This paper described the required information for SOA modelling techniques and some methods to exchange between U.S. Department of Defence (DoD) and commercial tools.
[71]	2011	Modelling Cloud SaaS with SOA and MDA	MDA-SOA-Cloud	This paper highlighted merging Cloud Computing, SOA, and MDA in progress of optimal business solutions.
[76]	2012	On-Demand Service-Oriented MDA Approach for SaaS and Enterprise Mashup Application Development	MDA-SOA-Cloud	This proposed an On-Demand Service-Oriented Model Driven Architecture approach that applies Service Oriented Architecture (SOA) elements into MDA to develop an enterprise mashup prototype.

6. Vision for MDA-SOA based Intercloud Interoperability

The aim of current article is introduce an Intercloud Interoperability framework based on SOA and MDA approaches for particular GE in FI-WARE Cloud. In order to show the distinctive ways of interaction between cloud users and providers, NIST [77] defined following *use cases for Cloud Computing Interoperability*:

- Copy Data Objects Between Cloud-Providers
- Dynamic Operation Dispatch to IaaS Clouds
- Cloud Burst from Data Center to Cloud
- Migrate a Queuing-Based Application
- Migrate (fully-stopped) VMs from One Cloud Provider to Another

Lewis [78] after studying use cases proposed by NIST and OMG, presented four main cloud interoperability use cases that can benefit from current standards:

1. User Authentication: A user who has established an identity with a cloud provider can use the same identity with another cloud provider.
2. Workload Migration: A workload that executes in one cloud provider can be uploaded to another cloud provider.
3. Data Migration: Data resided in one cloud provider can be moved to another one.
4. Workload Management: Custom tools developed for cloud workload management can be used to manage multiple cloud resources from different vendors.

The overall vision for MDA-SOA based inter-cloud interoperability to achieve the scenarios as explained is as shown in Fig. 15. A cloud based application makes use of the framework to interoperate with other clouds. Application accesses the functionality of the framework through the interfaces defined by the framework.

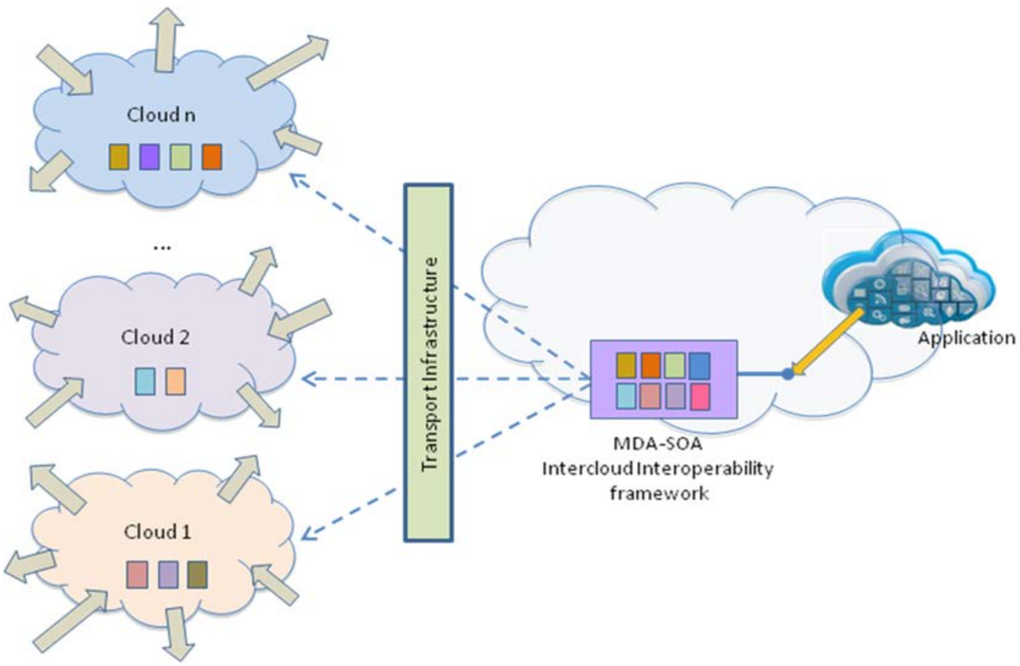

Fig. 15. MDA-SOA Intercloud Interoperability Framework.

XMPP is emerging as the transport protocol for inter cloud communication. In "Using XMPP as a transport in Intercloud Protocols" [32], Bernstein and colleagues has been claimed that Point to Point protocols are not advisable for Intercloud Protocols and accordingly many-to-many mechanisms including Messaging and Presence Protocol (XMPP) for transport are the appropriate way to communicate. MDA-SOA framework makes use of such standard communication protocol and other communication infrastructure as the Transport infrastructure. Transport Infrastructure is an important aspect of studies for inter-cloud interoperability, bus is out scope of this paper. In the following section, vision for MDA-SOA inter-cloud interoperability is described with further details.

6.1. Generic Architecture

The SOA-MDA inter-cloud generic architecture aims to resolve interoperability incompatibilities between heterogeneous Cloud computing Platforms. This architecture utilizes the knowledge driven from emerging IT trends such as MDA, SOA, semantics and also provides an interface for integration of other applications being developed to perform various tasks in the paradigm of cloud computing. The architectural pattern to be followed by the generic architecture is based on the discussion in sections 3 and 4. It comprises of two horizontal layers, the MDA-SOA Layer, the Enablers-Integration Layer and two vertical layers, namely the Semantics Layer and the Inter-Cloud Layer, that span across all the horizontal ones. A high-level view of the generic architecture is as shown in Fig. 16:

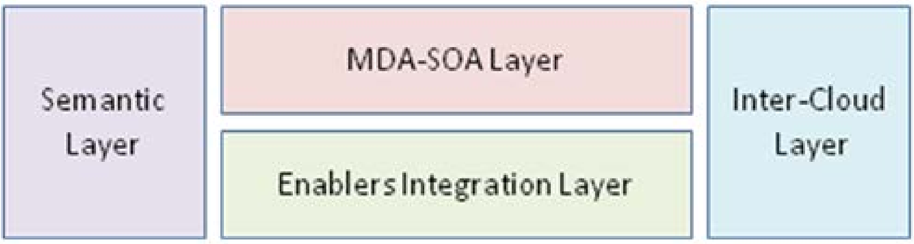

Fig. 16. A high-level view of the generic architecture.

The MDA-SOA Layer implements the core functionalities offered by the overall framework that will support major interoperability related operations. The *Enablers Integration layer* provides the interfaces for integration of third party cloud-based applications into the generic architecture, so as to achieve some specific tasks. The *Semantics Layer* provides the functionality to maintain and utilize the semantic models that will be necessary to obtain interoperability. The *Inter-Cloud Layer* puts in place the technical infrastructure related to independent clouds, which provides necessary information for all the horizontal layers. All of these functionalities will be exposed through well define interfaces like web service which provides an easy access for the MDA-SOA Framework functionalities.

6.1.1. Semantic Layer

The backbone layer of the architecture is the Semantic Layer (shown in Fig. 17.). Its components, named Application Model, Data Model and Cloud Offering Model, span the entire architecture resolving semantic interoperability conflicts that are raised between different clouds. Semantics are used by the MDA-SOA Layer in order to provide the means for developing interoperability related mechanisms.

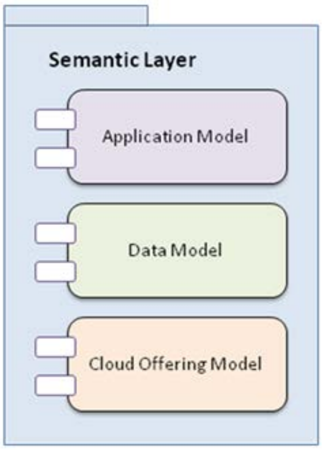

Fig. 17. Semantic Layer.

It is to be noted that Cloud Offering Model is the top level abstraction component to generalize different models of cloud offering. In any instance, this can be implemented by SaaS, PaaS or IaaS Offering Model, based on the use-case(s) for which the inter-cloud interoperability framework is being used.

6.1.2. MDA-SOA Layer

The MDA-SOA Layer, lies on top of the Enablers Integration Layer, and comprises of a components that will be accessible from top layer application interface layer, with well defined interfaces. Its components capitalize on the semantic annotation of the Semantic Layer and the functionalities of the inter-cloud layer to offer various cloud resources discovery and selection based on the requirements of the service consumer application which is obtained through the top layer i.e. application interface layer. At the same time, this layer makes use of enablers integration layer to achieve some specified tasks, based on the functionality provided by the enabler. On the whole, MDA-SOA layer acts as the mediator layer between all the other layers. This layer makes extensive use of the concepts and principles that have been discussed in sections 3 and 4. MDA-SOA Layer and its components are depicted in Fig. 18Error! Reference source not found.

Fig. 18. MDA-SOA Layer.

- **Model Manager**: The Model Manager module uses the Cloud-Offering Model, the Application Model and the Object Model in order to retrieve the semantic concepts related to the corresponding object instances.
- **Transformation Engine**: Transformation Engine is responsible to perform model transformations based on the interoperability requirements. This engine makes extensive use of model manager to define the transformation strategy, based on the requirements of the clouds under interaction.
- **Cloud-Offering Discovery and Selection**: This component provides the functionality for cloud-offering discovery and selection from heterogeneous clouds. The Cloud-Offering Discovery and selection components capitalize on the search mechanisms and information offered by the inter-cloud Layer and employs lightweight semantic models and techniques in order to find among the available cloud offerings which meets the current work-flow requirements. These requirements are based on the models under considerations and the QoS specifications provided by service consumer that uses the framework. Note that this is a high level abstraction component which will be implemented by SaaS, PaaS or IaaS Offering Discovery and Selection components, as required by the application scenario.
- **Process Executor**: This component is primarily responsible for the execution of the business process, which defines the sequence of operations to be performed to achieve some specific task. In the architecture that we have proposed, we can observe that the components are separated and provide specialized functionality and also have the provision to integrate third party services/applications. So, this component is very important and it executes processes by interpreting them and evaluating their execution conditions. Every activity of the process model defined will be evaluated and the ones that satisfy the business conditions for the current work-flow would be executed.

6.1.3. Enablers Integration Layer

Interoperability between clouds will arise because of different use-case scenarios, which will require providing various implementations based on the problem domain. This, layer acts as the point of integration for such implementations which are termed as enables in this paper. So, the lower layer of the architecture provides an open space to integrate third party implementations, a example of which will be provided in section X as applicable for that particular scenario. The components being integrated in this layer virtually can be anything -service or application and will communicate with other layers or are used by other layers through well defined interfaces. So, in the generic architecture this layer is just an abstraction layer, and doesn’t require any predefined components, because this layer doesn’t implement any specific functionality.

6.1.4. Inter-Cloud Layer

One of the vertical layers of the generic architecture inter-cloud layer involves the appropriate capabilities that enhance the selection of specific providers form the network of cloud providers. Its main components support search and discovery mechanisms with the help of repositories. At the same time they support the selection mechanism by providing the profile of the cloud providers through QoS and SLAs repositories. This layer makes use of the SOA and Cloud computing principles as discussed in section 2. An abstract view of the Inter-Cloud Layer is presented in Fig. 19.

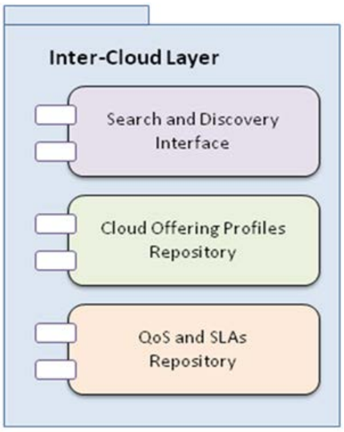

Fig. 19. Inter-Cloud Layer.

- **Search and Discovery Interface**: This component is responsible for searching among the available cloud offerings from the network of cloud providers. On the one hand there is a set of application requirements in the form of resources and restriction upon them and on the other hand there is a set of cloud offerings that express capabilities of the respective Cloud providers. The purpose of this component is to match the needs and offers producing a matching score.
- **Cloud Offering Profiles Repository**: This component serves as a simple registry for browsing over the available cloud offerings. A cloud offering is defined as a set of software, infrastructure or resources and is provided by one offering party. Such a party may provide more than one offerings.
- Note that both of these components are the high level abstraction components for cloud. Depending on the case of the use these will be inherited or implemented by IaaS, SaaS or Paas Search and Discovery Interface and IaaS, SaaS or Paas Offering Profiles Repository.
- **QoS and SLAs Repository**: A Service License agreement (SLA) is essentially a bridge between a cloud offering and application requirements set (Application Profile). It represents an agreement between the Cloud provider and the Cloud based application owner who is the consumer of the available services. Each SLA defines recovery actions if restrictions cannot be satisfied. At the same time QoS properties for each services of the cloud provider are provided by this repository which will be used for making the correct selection of the cloud provider (or the provided services) based on the requirements of the service consumer.

6.2. Scenario for job scheduling in Intercloud paradigm

In order to further explain the proposed framework, this paper selects “Workload Migration” as an interoperability use case, which is for workloads independent from unique resources of a specific cloud-provider and its task is dynamically dispatch the operations to the clouds. In, this scenario, Job Scheduler GE[3] from FI-WARE cloud hosting architecture can be integrated in the *Enablers Integration Layer*. The Job Scheduler GE is an enabler to execute a task over distributed multiple heterogeneous computer systems, both physical and virtual ones introduced in FI-WARE Cloud Architecture. Exploiting our Intercloud Interoperability framework for job scheduling GE will provide the job submission and its life-cycle control through available computing resources on some other cloud vendors.

Based on the scenario, an instance of the generic architecture is as shown in Fig. 20. In this scenario, the top level abstract components for cloud, are instantiated with the implementations for IaaS paradigm for cloud computing. The overall framework provides interfaces for job submission and model submission. Consumer application now interacts with the framework, the big picture of which is as shown in Fig. 15.

[3] http://forge.fi-ware.eu/plugins/mediawiki/wiki/fiware/index.php/FIWARE.OpenSpecification.Cloud.JobScheduler

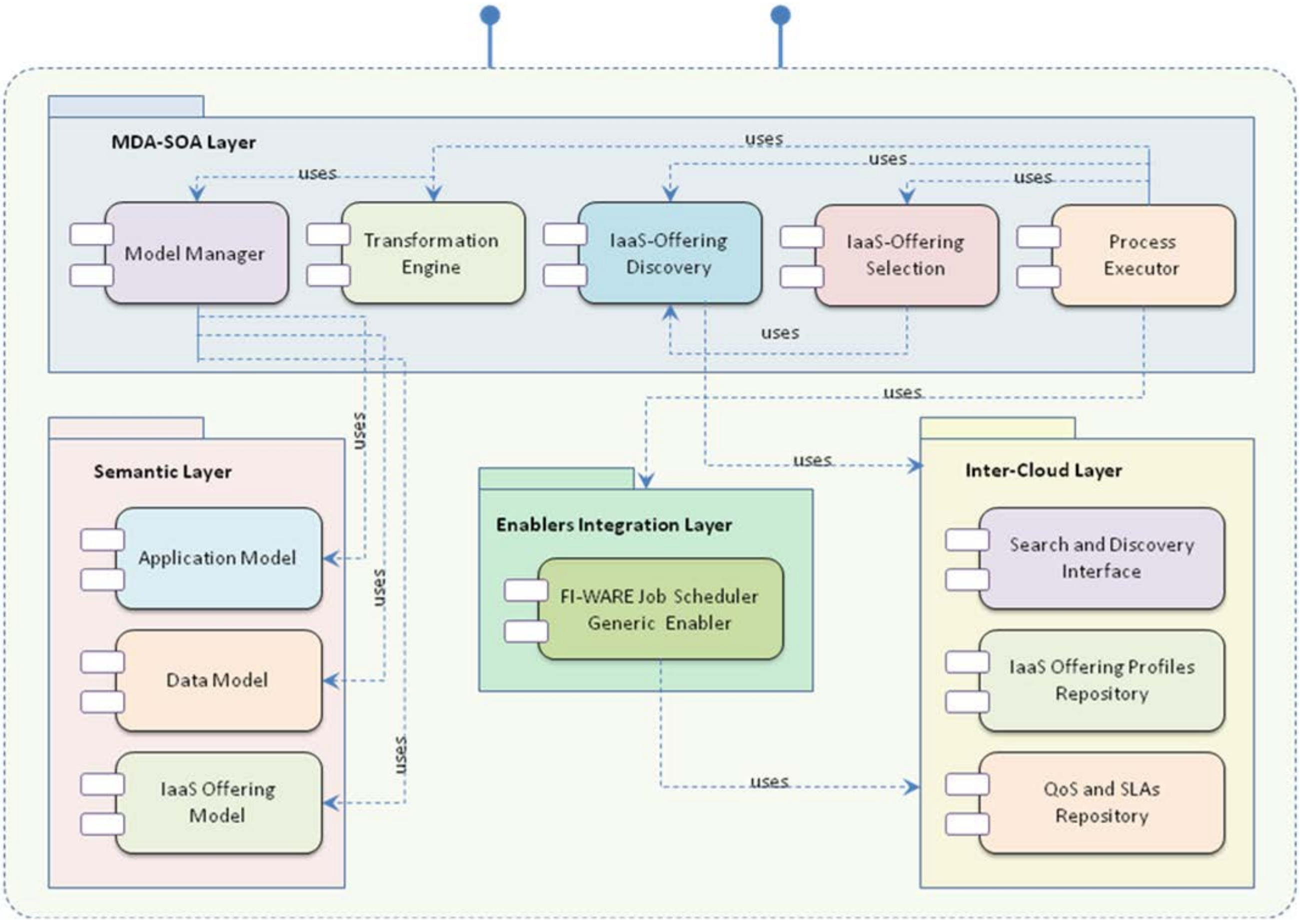

Fig. 20. Generic architecture for job scheduling in intra-cloud paradigm.

The sequence of activities that will take place can be depicted by the following steps:

1. Framework receives event for job dispatch from the service consumer, through its interface for consumer applications.
2. Service consumer provides the job details (Object Models, Operation Models etc.), through the service interface exposed by the framework, which is handled by the Model Manager module of the framework.
3. If applicable i.e. if the task is critical, service consumer also provides the QoS requirements for the task.
4. Upon reception of all the job details and necessary requirements, process executor engine initiates the workflow and keeps track of all the activities.
5. Resource search and discovery module of the framework looks up for the available resources in other cloud and acquires the specified QoS and other functions specifications.
6. Resource selection module makes use of the requirements obtained in step 3 and provider specification obtained in step 5, to select the set of clouds that will be used for job dissemination. At this stage the IaaS offering selection module makes use of IaaS Offering Model to make the best suited selection.
7. Transformation Management performs the necessary model transformation for the job details obtained in step 2 as per the specification of the resources selected in step 6 and its details obtained in step 5. At this point the semantics layer will be used to make the necessary transformations.
8. Framework makes use of the Job scheduling GE to schedule the job to the selected resources in step 5 with the transformed model obtained in step 6
9. Selected resource executes the job and returns back the result.
10. Framework collects the results, performs necessary transformations (if necessary) and is sent back to service consumer.

7. Conclusion and future work

Cloud computing has emerged as a new and promising paradigm and includes managing heterogeneous, private/public/hybrid clouds and delivering services over the Internet. Many challenges exist in the area of Cloud Computing which can be an obstacle for its adoption by organizations to outsource applications with sensitive information over cloud environment. This paper tries to address one major challenge which is Intercloud Interoperability that is based on the fact that each single cloud has limited computing resources in a restricted geographic area. Intercloud Interoperability will enable cloud providers to deliver better quality of services, avoid data lock-in, and reduce scaling/producing costs.

Since, there is still no implicit solution to promote Intercloud Interoperability; we are working on a framework to achieve better Intercloud Interoperability. In order to devise the best approaches for implementation of our framework, current research approaches to Intercloud Interoperability, Cloud Computing, and different application design approaches were studied. Our research shows that recently, Model Driven approaches from OMG and SOA methodology are increasingly exploited to develop different frameworks to solve several issues such as interoperability in enterprises. This paper includes the main concepts in cloud computing and additionally the concept and state-of-the-art in intercloud interoperability. Moreover, in order to have better understanding of MDA and SOA approaches to implement Intercloud framework, this paper describes the capability of MDA and SOA approaches to enhance the interoperability among clouds as well as current state of the art in utilizing these approaches. This paper also proposes a generic framework based on the principles of MDA and SOA, to be used to resolve the intercloud interoperability issues. The generic architecture of the framework not only takes into account of the general MDA and SOA patters but also integrates other important aspects of interoperability like semantics and loose coupled third party services integration. The functioning of the framework is described by providing a specific instantiation of the generic architecture in the paradigm of the job migration into heterogeneous clouds. In this particular use-case, an implementation provided by FI-WARE is integrated into the framework to achieve some specific functionality.

This paper opens up lots of future work to be undertaken in the aspect of intercloud interoperability. One important future task will be to work on the development of the framework based in the concepts that have been proposed and study applicability in some real case business scenarios. Development of such framework will help in the adoption of intercloud by both cloud providers and consumers. At the same time other important future task that can be undertaken is to study other paradigms of inter-cloud as discussed in section 6 and resolve by using or extending the framework that has been proposed in this paper. A number of other cloud related generic enablers are being developed by FI-WARE project, which can be integrated with the proposed framework to study other paradigms where intercloud will be equally important and challenging.

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Agent-based approach to model parallel and concurrent negotiations

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Abstract

Each organization has limited resources and in order to better accomplish a higher external demand, the managers are forced to outsource parts of their contracts even to concurrent organizations. In this concurrent environment each organization wants to preserve its decision autonomy and to disclose as little as possible from its business information. To model this interaction our approach is to define a framework for describing and managing parallel and concurrent negotiations among independent organizations acting in the same industrial market. The complexity of our negotiation model is done by the dynamic environment in which multi-attribute and multi-participant negotiations are racing over the same set of resources. We are using the metaphor Interaction Abstract Machines (IAMs) to model the parallelism and the non-deterministic aspects of our negotiation process.

Keywords: Negotiation model, intelligent agents, computational method, dynamic environment, constraint satisfaction programming.

1. Introduction

The advent of the Internet and more recently the cloud-computing trend have led to the development of various forms of virtual collaboration in which the organizations are trying to exploit the facilities of the network to achieve higher utilization of their resources. We try to provide support to these collaboration activities and we propose negotiation as a fundamental mechanism for such collaborations.

In this paper we present how organizations participate and control the status of the negotiations and how the negotiation processes are managed. We propose a framework for coordinating parallel negotiations occurring in a business-to-business interaction.

We consider a scenario of distributed autonomous business organizations (e.g., carpentry workshops). Each organization autonomously manages its contracts, schedules and resources. When a new task request reaches an organization, the manager analyses its acceptance taking into account the current schedule and the resources availability. After the manager accepts the new job task, he may decide to perform it locally or to partially outsource it. If the manager decides to outsource a job, he starts a negotiation within the collaborative infrastructure with selected participants. The manager may split the job into slots, notifying the partners about the outsourcing requests for the different slots. If the negotiation results in an agreement, a contract is settled between the outsourcer and the insourcer organization, which defines an inter-organizational workflow enacting the business process fulfilling the outsourced jobs and a set of obligation relations among participants [1]. Each partner organizations may a priori be in competition with each other, but may want to cooperate in order to be globally more responsive to market demand. This collaborative infrastructure should flexibly support negotiation processes respecting the autonomy of the partners. The main objective of this paper is to propose a framework for modelling parallel negotiations in a dynamical system with autonomous organizations. In Section 2, we describe a formal interaction model to manage multiple concurrent negotiations. Section 3 presents an example for modelling the negotiation process by using the metaphor Interaction Abstract Machines (IAMs). In section 4, we briefly present the architecture of the negotiation

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system in which the interactions take place and describe the coordination services that manage different negotiations which may take place simultaneously [2]. Also, we present how the proposed model can be used for describing a particular coordination negotiation service. Finally, Section 5 concludes this paper.

2. Building the Negotiation Model

In this section we propose a formal model to settle and to manage the coordination rules of one or more negotiations, which can take place in parallel. First, we define the basic concepts underlying the model and then, by using the metaphor of Interaction Abstract Machines (IAMs), we describe the negotiation model. We introduce the Program Formula to define the methods used to manage the parallel evolution of multiple negotiations.

2.1. Fundamental Concepts

In this setup, at a local level, the model requires a formal description of the rules of coordination that manage the behavior of the agent in a negotiation; at a global level, the model must provide a global coordination of all negotiations of an agent.

The fundamentals of the negotiation model are given by the following basic concepts:

A *Negotiation Model* is defined as a quintuple M = <T, P, N, R, O> where:

- T denotes *the time of the system*, assumed to be discrete, linear, and uniform [3];
- P denotes *the set of participants* in the negotiation framework. The participants may be involved in one or many negotiations;
- N denotes *the set of negotiations* that take place within the negotiation framework;
- R denotes *the set of policies of coordination* of the negotiations that take place within the negotiation framework;
- O denotes *the common ontology* that consists of the set of definitions of the attributes that are used in a negotiation.

A *negotiation* is described at a time instance through a set of negotiation sequences.

Let Sq = {si | i $\in \mathbb{N}$} denote the set of *negotiation sequences*, such that $\forall$si ,sj $\in$ Sq, i $\neq$j implies si $\neq$ sj. A *negotiation sequence* si $\in$ Sq such that si $\in$ N(t) is a succession of negotiation graphs that describe the negotiation N from the moment of its initiation and up to the time instance t. The negotiation graph created at a given time instance is an oriented graph in which the nodes describe the negotiation phases that are present at that time instance (i.e., the negotiation proposals sent up to that moment in terms of status and of attributes negotiated) and the edges express the precedence relationship between the negotiation phases.

The *negotiation phase (ph)* indicates a particular stage of the negotiation under consideration.

The *Status* is the possible state of a negotiation. This state takes one of the following values *(Status $\in${initiated, undefined, success, failure}*):

- *initiated* – the negotiation, described in a sequence, has just been initiated;
- *undefined* – the negotiation process for the sequence under consideration is ongoing;
- *success* – in the negotiation process, modeled through the sequence under consideration, an agreement has been reached;
- *failure* – the negotiation process, modeled through the sequence under consideration, resulted in a denial.

Issues is the set of attributes with associated values that describe the proposals made in a negotiation phase.

Snapshot is the set of combinations between a negotiation aspect (*Status*) and the information that is negotiated (*Issues*).

The functions *status* and *issues* return, respectively, the state (status) of a negotiation instance and the set of the attributes negotiated (issues) within a negotiation instance. A *coordination policy* is the set of coordination rules that are used to establish various relationships between negotiations regarding the information that may be distributed among many participants and many sequences (global rules) or that may be recovered as a whole in the same sequence (local rules).

2.2. Metaphor Interaction Abstract Machines (IAMs)

The metaphor Interaction Abstract Machines (IAMs) will be used to facilitate modeling of the evolution of a *multi-attribute, multi-participant, multi-phase negotiation*. In IAMs, a system consists of different *entities* and each entity is characterized by a state that is represented as a set of *resources* [4]. It may evolve according to different laws of the following form, also called *"methods"*:

A1@…@An <>- B1@…@Bm

A method is executed if the state of the entity contains all resources from the left side (called the *"head"*) and, in this case, the entity may perform a transition to a new state where the old resources (*A1,…,An*) are replaced by the resources (*B1,…,Bm*) on the right side (called the *"body"*). All other resources of the entity that do not participate in the execution of the method are present in the new state.

The operators used in a method are:

- the operator @ assembles together resources that are present in the same state of an entity;
- the operator <>- indicates the transition to a new state of an entity;
- the operator & is used in the body of a method to connect several sets of resources;
- the symbol "T" is used to indicate an empty body.

In IAMs, an entity has the following characteristics:

- if there are two methods whose heads consist of two sets of distinct resources, then the methods may be executed in parallel;
- if two methods share common resources, then a single method may be executed and the selection procedure is made in a non-deterministic manner.

In IAMs, the methods may model four types of transition that may occur to an entity: *transformation*, *cloning*, *destruction* and *communication*. Through the methods of type *transformation* the state of an entity is simply transformed in a new state. If the state of the entity contains all the resources of the head of a transformation method, the entity performs a transition to a new state where the head resources are replaced by the body resources of the method. Through the methods of type *cloning* an entity is cloned in a finite number of entities that have the same state. If the state of the entity contains all the resources of a head of a cloning method and if the body of the method contains several sets of distinct resources, then the entity is cloned several times, as determined by the number of distinct sets, and each of the resulting clones suffers a transformation by replacing the head of the method with the corresponding body. In the case of a destruction of the state, the entity disappears. If the state of the entity contains all the resources of the head of a transformation method and, if the body of the method is the resource T, then the entity disappears.

In IAMs, the *communication* among various entities is of type broadcasting and it is represented by the symbol "^". This symbol is used to the heads of the methods to predefine the resources involved in the broadcasting. These resources are inserted in the current entity and broadcasted to all the entities existent in the system, with the exception of the current entity. This mechanism of communication thus executes two synchronous operations:

- *transformation:* if all resources that are not pre-defined at the head of the method enter in collision, then the pre-defined resources are inserted in the entity and are immediately consumed through the application of the method;
- *communication:* insertion of the copies of the pre-defined resources in all entities that are present in the system at that time instance.

2.3. Program Formula

In a multi-entity system, the metaphor IAMs allows the modeling and control of the autonomous evolution process for each entity in the system. Each entity may change its state independently of others, using its own resources and the methods of its computational space. This approach allows us to model in parallel the evolution of multiple negotiation phases. By using the metaphor IAMs, the evolution of the negotiation phases, associated to the nodes of a negotiation sequence, will be managed through different methods that are put together in a *Program Formula (PF)*. Program Formula of a negotiation sequence *s - PF(s)* – represents the set of the methods used to manage the evolution of the sequence s.

In our negotiation model, a negotiation phase is connected to the set of snapshots of the negotiation status and of the instants of the attributes negotiated that are present in a node of the negotiation graph. In this way, to specify not only the information regarding the negotiation state and the attributes values but also the actions that will contribute to the evolution of the negotiation, we model the nodes of a graph of the negotiation sequence as sets of particles, called *negotiation atoms*. Therefore, a negotiation atom, denoted *atom(s,ph)*, is a set of resources, called *particles*, that describe the negotiation state in terms of the negotiation sequence s for the negotiation stage *ph*.

We defined in this way five types of particles: *representation* particles, *event* particles, *message* particles, *control* particles, and *computational* particles.

In our negotiation model, a negotiation sequence keeps, in the nodes of the graphs, sets of snapshots, images that a participant has about the negotiation status and about the attributes that are negotiated in the current sequence as well as in all other sequences for which there is a distribution of information. This information is modeled within the negotiation process as *representation particles* that are described by three parameters (*Name, S, and I*):

- *Name* is defined by concatenation of the identifiers of the participants with the sequence under consideration (e.g., *pjsj*).
- *S* takes values in the set *Status = {initiated, undefined, success, failure}.* This value corresponds to the value returned by the function *status().*
- *I* takes values in the set Issues of the negotiated attributes with the associated values. This value corresponds to the value returned by the function *issues().*

In this way, a representation particle of an atom, associated to a sequence s for a phase *ph*, is a snapshot of the sequence s for the phase *ph*. To provide a detailed description of the negotiation sequences involved in a negotiation phase, we define the following particles:

- *localr(Name, S, I)* : local representation particle. This particle holds the local snapshot of the current sequence;
- *extr(Name, S, I)* : external representation particle. This particle holds the external snapshot that describes the modality in which another sequence perceives the same negotiation phase;
- *firstr(Name, S, I)* : external negotiation particle. This particle holds the external snapshot associated to the sequence that generated the current sequence.

In this way, a new node of a negotiation sequence may be described through a set of representation particles that are part of the same atom.

The particles *event* specify the types of transitions used by IAMs in terms of the message types that are exchanged within a negotiation. A particle event is described by three parameters:

- *Id* identifies the atom to be cloned;
- *New_id* identifies the newly created atom;
- *Msg* contains the negotiation message with data that will contribute to the evolution of the negotiation in the newly created atom.

To facilitate the identification of both the cloning operation and of the direction in which the new negotiation atom will evolve, we propose four particles event: *clone_propose, clone_accept, clone_reject*, and *clone_create*. The particles *clone_propose*(Id, New_id, Msg), *clone_accept*(Id, New_id, Msg), and *clone_reject*(Id, New_id, Msg) are modeling an event that signals the existence of a new negotiation message of type *propose*, of type *accept*, and of type *reject*, respectively. The particle *clone_create*(Id, New_id, Msg) models an event that signals the existence of a new negotiation message that announces creation of a new sequence for the current negotiation.

The particles *message* model the messages sent to allow their processing in terms of their interpretations in a typical negotiation process. The particles *message* have the following parameters:

- *Rname* and *New_r_name* are identifiers of the sequence that generates the message and of a new sequence that is invited to negotiation, respectively.
- *Content* represents the content of the message which is a proposal regarding the negotiation task.
- *Type* represents an identifier of the new coordination policy that satisfies a certain pattern and that must be managed by the sequence invited to negotiation.

We propose four types of message particles: *propose*, *accept*, *reject*, and *create*.

The particle *propose(Rname, Content)* signals the existence of a new proposal in the negotiation process, and the particles *accept(Rname)* and *reject(Rname)* signal the existence of an acceptance of a proposal and the existence of a denial of a proposal, respectively. The proposal to accept and, respectively, to deny was sent by a participant in the negotiation through the sequence Rname.

The particle *create(New_r_name, Type)* signals the existence of a new sequence that is part of the current negotiation phase and that is identified by *New_r_name*.

To properly formulate a coherent execution of a negotiation process, we introduced the *control* particles. These particles have several functions in the computation space of a negotiation sequence:

- an identification function (e.g., *name(Id)*) that identifies the negotiation atoms by specifying an unique value to the parameter *Id* for each atom. This unique value allows only to the specified atom to consume various events introduced in the system that are addressed to this atom;
- a limitation function (e.g., *start(), enable(), freeze(), waiting()*) that introduces the concept of control over the methods that may induce errors in negotiation. This type of particles limits the number of methods that may be executed in a given state. In this manner, we may establish a proper succession in the execution of certain methods. For example, we will use the particles *enable* and *freeze* to favor the methods to consume the events and to consume the messages, respectively. Through the aid of these two methods we will introduce a well-defined order in the negotiation process, first the creation of a negotiation atom and, second, the evolution of the negotiation phase in this newly created atom;
- a notification function (e.g., *stop(Accord), ready(Accord)*).

Handling and creating negotiation proposals is performed through *computational* particles. Using the notion of *raw computation* introduced by IAMs, we assume that each atom contains implicit in his state particles that processes various negotiating proposals in terms of mathematical operations or of strings manipulations. For example, the particle *{construct (I1, Content, I)}:* given the previous instantiation of the negotiated attributes (*I1*) and new values of the attributes of the proposal made in *Content*, the *construct* particle builds the new instance of the attributes (*I*).

3. Modelling the Negotiation Process

According to our approach regarding the negotiation, the participants to a negotiation may *propose* offers and each participant may decide in an autonomous manner to stop a negotiation either by *accepting* or by *rejecting* the offer received. Also, depending on its role in a negotiation, a participant may *invite* new participants to the negotiation. To model this type of negotiation, we will make use of the previously defined particles and we will propose the methods to manage the evolution of these particles.

As we have seen, a characteristic of negotiation is its multi-node image, which allows parallel development of several phases of negotiation. A possibility to continue a negotiation is to create a new phase of negotiation from an existing one. In this regard, the Figure 1 presents the possible evolutions of a ph0 phase of negotiation described by the *atom (s,ph0)*.

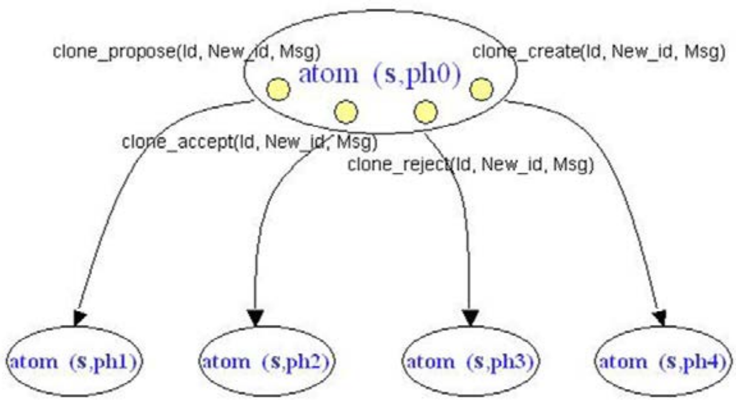

Fig. 1. Evolution of negotiation process by cloning an atom

In accordance with the aspects of negotiation for which changes are made, three new negotiation phases are possible:

- evolution of negotiated attributes and / or of their value from *atom(s,ph0)* to *atom(s,ph1):* a participant sends a new proposal thus achieving either the *contraction* of the negotiation attributes, or their *extension*, by the introduction of new attributes to negotiate;
- evolution of the negotiation status perceived by one of the sequences sharing the new negotiation phase: one of the participants accepts - *atom(s,ph2)* - or refuses a proposal - *atom(s,ph3)*;
- evolution of participants and of dependences among negotiations by the evolution of the number of sequences sharing the same negotiation phase: a sequence can invite a new sequence to share a new phase of negotiation *atom(s,ph4).*

Through the use of the metaphor IAMs, the evolutions of the negotiation phases correspond to the evolutions at the atoms level. The evolution may be regarded as a process consisting of two stages: a *cloning* operation of the atom existent in the initial stage and a *transformation* operation within the cloned atom to allow for the new negotiation phase.

The *cloning* operation is expressed by a set of methods involving the particles *event* and these methods are used to facilitate the evolution of the negotiation.

We propose the following methods associated to the particles *event* to model the cloning of an atom where new message particles are introduced:

- The method *Propose* is associated to the particle event *clone_propose(Id, New_id, Msg)* and models the introduction of a new proposal (*clone_propose*), made by one of the participants to the negotiation.

This method is expressed:

name(Id) @ enable @ clone_propose(Id, New_ id, Msg)<>- (enable @ name(Id)) & (freeze @ name(New_ id) @ propose(Rname, Content))

The atom identified by the particle *name(Id)* is cloned. The new proposal contained in the particle *propose(Rname, Content)* will be introduced in the new atom *name(New_id).*

- The method *Accept* is associated to the event particle *clone_accept(Id, New_id, Msg)* and models the case when one of the participants has sent a message of acceptance of an older proposal (*clone_accept*).

This method is expressed:

name(Id) @ enable @ clone_accept(Id, New_ Id, Msg) <>- (enable @ name(Id)) & (freeze @ name(New_ Id) @ accept(Rname))

The atom identified by the *name(Id)* is cloned. The acceptance message contained in the particle *accept(Rname)* will be introduced in the new atom *name (New_id)*.

- The method *Reject* is associated to the event particle *clone_reject(Id, New_id, Msg)* and models the denial of an older proposal (*clone_reject*) made by one of the participants.

This method is expressed:

name(Id) @ enable @ clone_reject(Id, New_ Id, Msg) <>- (enable @ name(Id)) & (freeze @ name(New_ Id) @ reject(Rname))

The atom identified by the particle *name(Id)* is cloned. The refusal message contained in the particle *reject(Rname)* will be introduced in the new atom *name(New_ id).*

- The method *Create* is associated to the event particle *clone_create(Id, New_id, Msg)*. This method models the invitation of a new sequence (*clone_create*) made by one of the participants for sharing the newly created negotiation phase.

This method is expressed:

name(Id) @ enable @ clone_create(Id, New_Id, Msg) @ <>- (enable @name(Id)) & (freeze @ name(New_Id) @ create(Rname, Type))

The atom identified by the particle *name(Id)* is cloned, and a particle *create(Rname, Type)* is introduced in the new atom *name(New_ id)* that will further generate the occurrence of a new representation particle for the new sequence participating in the negotiation.

These methods are described in a generic way. Thus, new particles may be added depending on how the current sequence builds negotiation graphs.

By these methods of the event particles, the duplication of an atom has been modeled, in which new message particles are introduced (Figure 2). In the new atom, the representation particles for the current negotiation phase remain identical with those of the first atom.

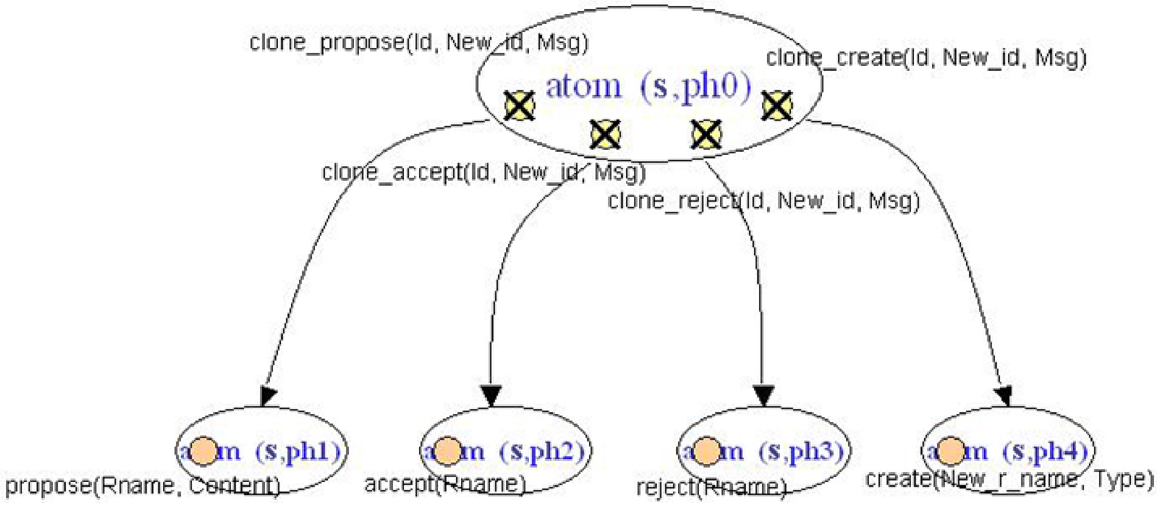

Fig. 2. Evolution of negotiation process by transformation of an atom state

According to our approach, the evolution of the negotiation process takes place by changing or creating a new negotiation phase. This phase can evolve according to: *i)* status; *ii)* attributes negotiated; *iii)* number of sequences participant in the negotiation, as in the following:

- The sequence of the statutes is the following: *i)* the sequence *s* finds itself in the *initiated* state at the creation of a first atom and of a first phase of negotiation; *ii)* the sequence s switches to the *undefined* state at the moment of emission or reception of a message; *iii)* if a participant accepts or declines a proposal, the s associated sequence may pass to a *success* or *failure* statute.
- Referring to the negotiated attributes (*Issues*), the different messages contribute to the evolution of the multitude of attributes and their values.
- The introduction of a new sequence in the current negotiation is modeled by inserting a new particle of representation on the current negotiation phase, which models the instant image of a new sequence on the current phase of negotiation.

In order to model these evolutions at the level of a negotiation phase, the message-type particles described above have been defined. The *message* particles participate in the transformation methods, which change the negotiation phase of an atom by replacing the representation particles of the negotiation sequences involved in the creation or in the reception of the exchanged messages.

In the following, we propose the basic forms of the *transformation* methods. Depending on the particular constraints of the negotiation, other transformation methods and other particles can be defined for modeling the foreseen constraints.

- The *transformation* method associated to a *propose(Rname, Content)* particle contributes to the local evolution of a negotiation phase regarding the status and the attributes negotiated. This evolution takes place by replacing, in the existing atom, all representation particles that are involved (depending on the method) with the new particles that have the status changed to *undefined*. Further, the set of the negotiated attributes (*Issues*) contains the new proposal expressed in the *Content* of the message particle.

freeze @ localr(Rname1, S1, I1) @ extr(Rname, S2, I1) @ propose(Rname, Content)<>- enable@ localr(Rname1, undefined, I) @ extr(Rname, undefined, I)

The atom changes the state by consuming the *propose()* particle as well as two representation particles to create new representation particles that describe the new proposal received.

- The transformation method associated to an *accept(Rname)* particle leads to the local evolution of a negotiation phase in terms of status. Evolution is achieved by replacing, within the corresponding atom, the representation particles involved, with the new particles whose status has been changed from initiated or undefined into success:

freeze @ localr(Rname1, S1, I1) @ extr(Rname, S2, I1) @ accept(Rname) <>- localr(Rname1, success, I1) @ extr(Rname, success, I1)

The atom changes the state by consuming the *accept()* particle and two representation particles to create the new representation particles whose status is changed in *success*.

- The transformation method associated to a *reject(Rname)* particle. This method is similar to the *accept(Rname)* particle, except for the fact that the evolution of the negotiation phase is achieved by changing the status of the representation particles concerned from initiated or *undefined* into *failure* :

freeze @ localr(Rname1, S1, I1) @ extr(Rname, S2, I1) @ reject(Rname) <>- localr(Rname1, fail, I1) @ extr(Rname, fail, I1)

The atom changes the state by consuming the *accept()* particle and two representation particles to create the new representation particles which have changed the status into *failure*.

- The transformation method associated to a *create(New_r_name, Type)* particle contributes to the evolution of a negotiation phase in terms of number of sequences that participate to this negotiation phase. This evolution is achieved by introducing, in the corresponding atom, a new representation particle:

freeze @ create(Rname, type) <>- extr(Rname, init, ∅) @ enable

As this sequence is just invited in the negotiation, its status is *initiated* and its set of the negotiated attributes is the empty set.

Thus, the negotiation phases and the evolution of these phases have been described using representation particles, event particles and message particles.

Given the fact that IAMs metaphor achieves a non-deterministic execution of the methods, we have introduced the *control* particles (see section 3.3) in order to counter this disadvantage and achieve a coherent execution of a negotiation process.

The evolution of all negotiation atoms and the negotiation phases take place in parallel.

To model the coordination of the execution of the negotiation process within a sequence, we used the communication mechanism among the existing negotiations. This type of particles that are part of the communication process among different negotiation atoms communicate to all negotiation atoms a certain result.

In the negotiation processes, the messages hold meta-information regarding the content of the messages that describe the proposals in terms of the value of different attributes of the negotiation object. We assume that all the negotiation participants use the same language and ontology.

Next section presents an example of modeling a negotiation composed of a set of negotiation sequences.

3.1. Example - modeling the negotiation process using the IAMs metaphor

In this example, a simple negotiation scenario will be presented, whose negotiation process corresponds to an exchange of proposals leading to an agreement.

In the proposed scenario, we consider a carpentry workshop of the p1 participant. The participant p1 decides to outsource a job (the assembling for 10K LM at a cost less than 2€/LM, within less than 5 days) to another carpentry workshop of a p2 participant.

The negotiation N that occurs between p1 and p2 is a bilateral negotiation.

It is described by two sequences: N(t) = {s1, s2} with s1∈sequences(t,p1), s2∈sequences(t,p2) and role(t,p1,N)=initiator, role(t,p2,N)=guest.

The scenario modeled subsequently takes place in three distinct steps:

- **step1** : after a first proposal made by participant p1 to participant p2, the participant p2 decides to send a new proposal;
- **step2** : the participants decide to agree on the second proposal;
- **step3** : the agreement is established and the negotiation stops.

Modeling takes place as it follows:

Step 1

Figure 3.a) shows the *s1* , *view(s1)= (p1,N,R1)* negotiation sequence with an a1 atom corresponding to a negotiation phase described by two representative particles, a local one and an external one, and two control particles, (*enable* and *name(a1)*). This atom can be considered as being the proposal made by p1 to p2 at the beginning of the negotiation.

Going on with the scenario, there is assumed that within the *a1* atom of the *s1* negotiation sequence, the *clone_propose(a1, a2, cost=18K delay=3)* event was introduced in order to announce a new proposal.

By using the *Propose* method, the *s1* negotiation sequence will contain two atoms (see Figure 3.b)): a1 atom that has changed by consuming the *clone_propose* particle and an a2 new atom, which is the a1 clone (representation particles not involved in the method remain unchanged in the two atoms). The expression of this method is:

name(Id) @ enable @ clone_propose(Id, New_ id, Msg)<>- (enable @ name(Id)) & (freeze @ name(New_ id) @ propose(Rname, Content))

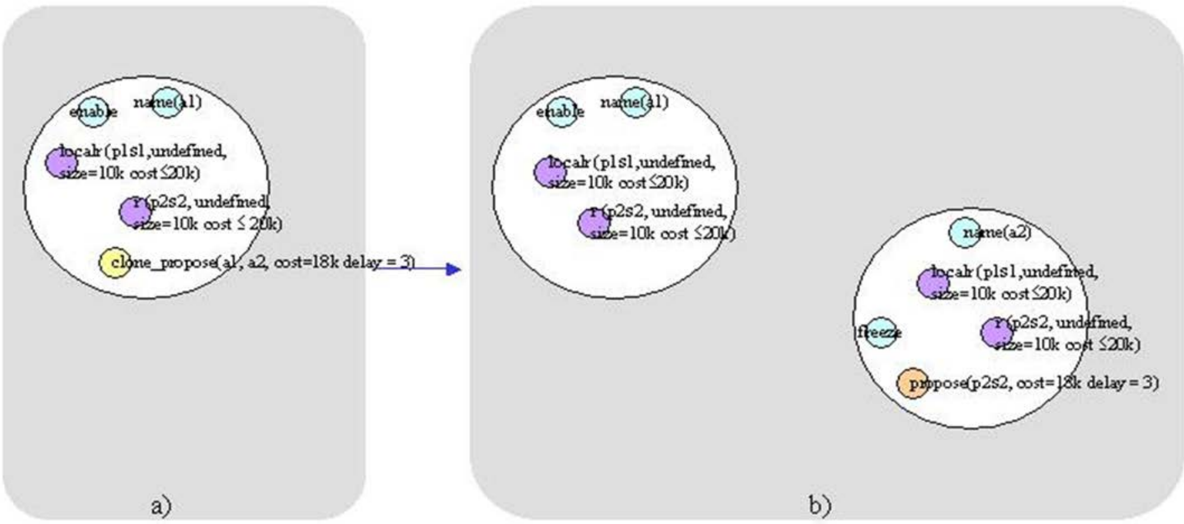

Fig. 3. a) – Proposal of p1 to p2 contained in a1atom

b) – Transformation of a1 atom in a2

From now on, the negotiation is described through the two negotiation atoms, in which the negotiation process can evolve independently.

The following methods will help us to model the fact that the (*name*, *freeze, propose*) new particles introduced in the a2 atom will make that the negotiation phase attached to this atom have a different evolution in comparison to that of a1 atom.

For the *propose* particle, the following method will be used:

freeze @ localr(Rname1, St1, I1) @ extr(Rname2, St2, I1) @ propose(Rname2, Content)<>- enable@ localr(Rname1, undefined, I) @ extr(Rname2, undefined, I)

This method exchanges the representation particles, which preserve the old values of the attributes, with the new representation particles that describe the new proposals received.

Thus, to move from an *extr(p2s2, undefined, size=10K cost≤20K)* representation particle, and from a *propose(p2s2, cost=18K delay=3)* message particle to an *extr(p2s2, undefined, size=10K cost=18K delay=3)* representation particle, the existence of a computational-type particle called *construct(I1,Content,I)* has been supposed, which calculates this transformation (see Figure 3.c)).

The expression of this method is:

freeze @ localr(Rname1, St1, I1) @ extr(Rname2, St2, I1) @ propose(Rname2, Content) @ {construct(I1,Content,I)} <>- enable @ localr(Rname1, undefined, I) @ extr(Rname2, undefined, I)

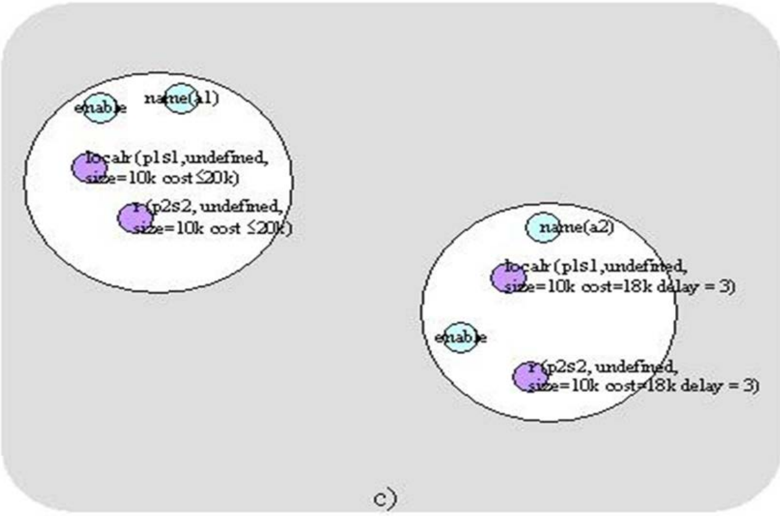

Fig. 3. c) Evolution of a1 and a2 atoms

Step 2

Further, we assume that p1 participant examines the two proposals and decides to accept the second proposal. Acceptance is modeled as follows:

i) the atom containing the proposals to be accepted is duplicated by *Accept* method associated to an event *clone_accept()* particle;

name(Id) @ enable @ clone_accept(Id, New_ Id, Msg) <>- (enable @ name(Id)) & (freeze @ name(New_ Id) @ accept(Rname))

ii) the clone atom evolves by consuming the *accept()* message particle;

freeze @ localr(Rname1, St1, I1) @ extr(Rname, St2, I1) @ accept(Rname) <>- localr(Rname1, success, I1) @ extr(Rname, success, I1)

Thus, in Figure 3.d) the s1 negotiation sequence of a p1 participant is composed of three negotiation phases. The third a3 atom contains a negotiation phase in which *success* is the negotiation status.

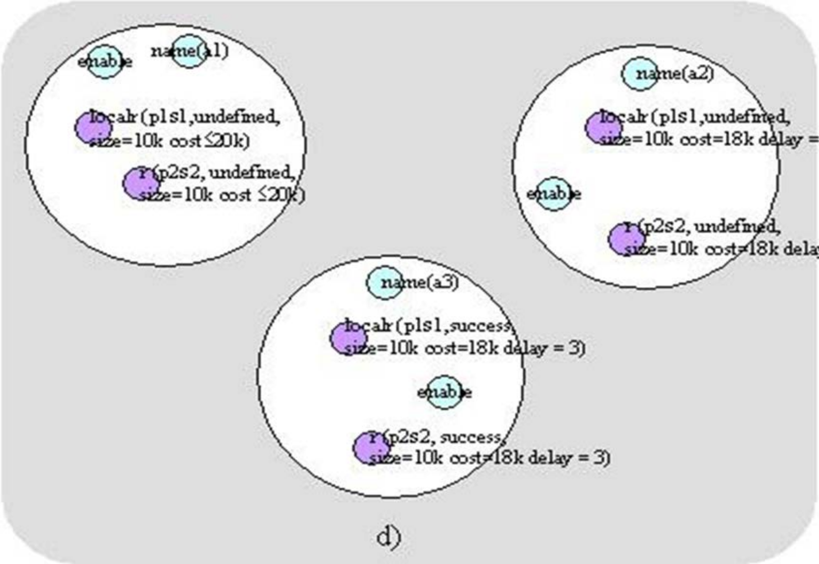

Fig. 3. d) Negotiation phases of the s1 sequence of a p1 participant

Step 3

The a3 atom can thus be perceived as the image of a negotiation phase on which the two participants have agreed. The existence of this agreement has to imply the fact that the negotiation has to come to an end.

In Figure 3.e), a3 atom changes its state and, at the same time, communicates to the other atoms to stop.

The expression of this method is:

localr(Rname1, success, I1) @ extr(Rname2, success, I1) @ ^stop(I1) <>- ready(I1)

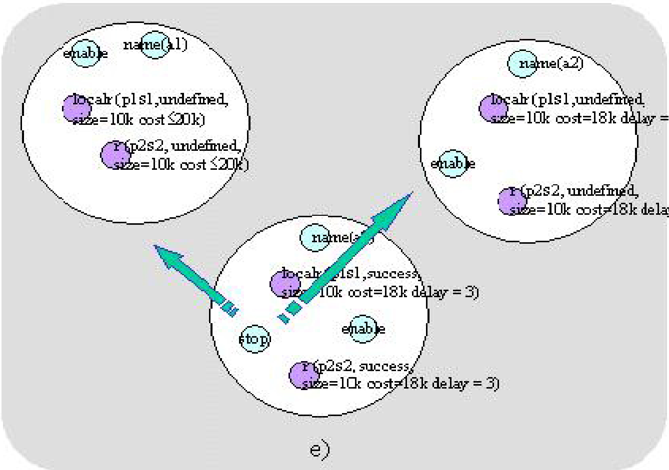

Fig. 3. e) Transformation of a3 atom state

The method stop <>- #t makes that, at a certain moment, the atoms containing *stop* particles be dissolved (see Figure 3. f.), the only active atom being the one containing the agreement (see Figure 3.g)).

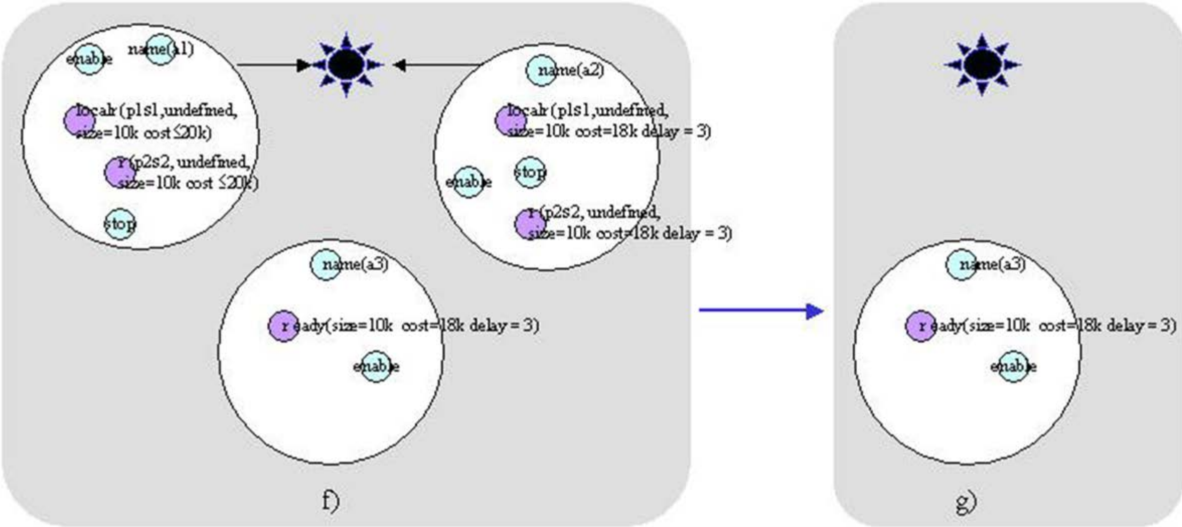

Fig. 3. f) Dissolution of a1 and a2 atoms containing stop particle

g) The active atom: a3 atom containing the agreement

Thus, in this section, the negotiation process by using the IAMs metaphor has been defined, and the negotiation composed of a set of negotiation sequences has been modeled. Each of these sequences was represented by a set of negotiation atoms, which, at their turns, each of them administrates independently a private negotiation phase as well as the set of the snapshots associated to the phase.

A snapshot describes the status of the negotiation and the set of the negotiated attributes. Also, a negotiation is characterized by the role of participants and the policy of coordination attached to it. These policies can be described by using different methods. The proposed model of the negotiation process allows describing the evolution of a negotiation by a parallel development of negotiation atoms associated to methods modeling the coordination policy.

In the next sections, the coordination model will be defined by using this describing model of the negotiation process. Our objective is to achieve a correspondence between the coordination policy that a sequence has to satisfy (static model), and the set of methods modeling the evolution in time of a negotiation sequence (dynamic model).

Given that each negotiation is composed of a set of negotiation sequences, the coordination process of one or more negotiations will be structured into modules (services) that correspond to the sequences involved in the negotiation.

In the next section, we will briefly describe the architecture of the negotiation system in which the interactions take place.

4. The Negotiation Infrastructure

The Negotiation infrastructure offers generic mechanisms to support negotiations in a distributed environment.

Figure 4 shows the architecture of the negotiation system:

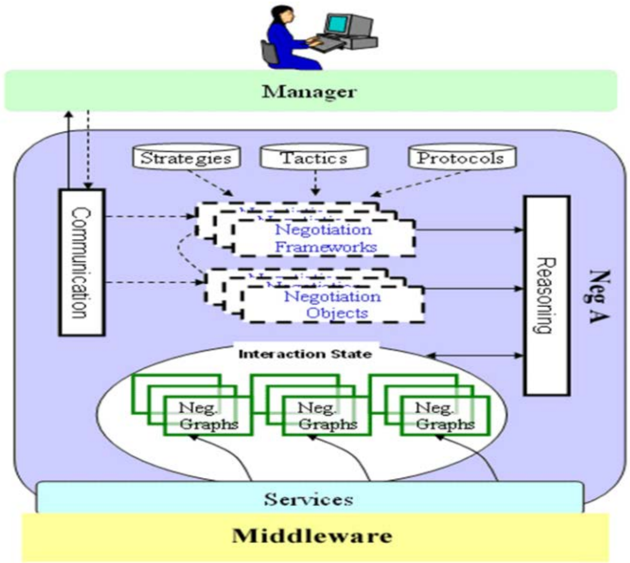

Fig. 4. The architecture of the negotiation system.

A Negotiation Agent (NegA) assists its manager at a global level (negotiations with different participants on different jobs) and at a specific level (negotiation on the same job with different participants) by coordinating itself with the NegA of the other partners through the coordination and negotiation middleware [5].

Each negotiation is organized in three main steps: initialization; refinement of the job under negotiation; and closing [6]. The initialization step allows to define what has to be negotiated (Negotiation Object) and how (Negotiation Framework) [7]. A selection of negotiation participants can be made using history on passed negotiation, available locally or provided by the negotiation infrastructure [8]. In the refinement step, participants exchange proposals on the negotiation object trying to satisfy their constraints [9]. The manager participates in the initial definition of negotiation frameworks and objects [10]. During the negotiation the decisions are taken by the manager, assisted by his NegA - decision functions operate in the “Reasoning” box (Fig.4). For each negotiation, a NegA manages one or more negotiation objects, one framework and the negotiation status represented as several graph structures. A manager can specify some global parameters: duration; maximum number of messages to be exchanged; maximum number of candidates to be considered in the negotiation and involved in the contract; tactics; protocols for the NegA interactions with the manager and with the other NegAs.

Differing from [11], where tactics are defined for managing the negotiation, here tactics define constraints on the negotiation process. For example, a tactic may state that a job has to be outsourced as a block, another one that it has to be split in several slots. Executing a tactic corresponds to activating a combination of services producing a coordinated modification of alternatives within the current negotiation [12]. Each service manages a local view of the global negotiation, translating negotiation decisions to modifications on the set of the visible alternatives on the job under negotiation using primitives of the negotiation middleware [13].

In order to handle the complex types of negotiation scenarios, we propose seven different services:

- *Outsrc:* the main service for a participant who initiates a negotiation for outsourcing jobs by exchanging proposals among participants known from the beginning;
- *Insrc:* the main service for a guest participant who is invited in a negotiation for insourcing jobs;
- *Block:* service for assuring that a task is entirely subcontracted by the single partner;
- *Split:* service manages the propagation of constraints among several slots, negotiated in parallel and issued from the split of a single job;
- *Broker:* a service for automating the process of selection of possible partners to start the negotiation;
- *SwapIn/SwapOut:* services implement a coordination mechanism between two ongoing negotiations in order to find and manage a possible exchange between their two tasks;

- *Transport:* service implements a coordination mechanism between two ongoing negotiations in order to find and synchronize on the common transport of both tasks.

These services are able to evaluate the received proposals and, further, if these are valid, the services will be able to reply with new proposals constructed based on their particular coordination constraints.

4.1. Coordination Services

According to our approach, the coordination problems managing the constraints among several negotiations can be divided into two distinct classes of services:

- Coordination services in a closed environment: services that build their images on the negotiation in progress and manage the coordination constraints according to information extracted only from their current negotiation graph (e.g., Outsrc, Insrc, Block, Split);
- Coordination services in an open environment: services that also build their images on the negotiation in progress, but they manage the coordination constraints according to available information in data structures representing certain characteristics of other negotiations currently ongoing into the system (e.g., Broker, Transport, SwapIn/SwapOut).

Following the descriptions of these services, we can state that unlike the services in a closed environment that manage the coordination constraints of a single negotiation at a time, the services in an open environment allow the coordination of constraints among several different negotiations in parallel. Thus, the introduction of coordination services level allows the management of all simultaneous negotiations in which a network partner can be involved. This level has two main functions:

- Mediation the transition between the negotiation image at the Negotiation Agent level and the image at the Middleware level;
- Allowing the implementation of various types of appropriate behavior in particular cases of negotiation.
- Consequently, each service is considered to correspond to a particular negotiation type.

Next section presents in detail the coordination services in a closed environment.

4.1.1. Outsrc Service

The *Outsrc* service is the main service of a negotiation. The automatic negotiation process is initiated by creating an instance of this service starting from the initial negotiation object. Further, this service must build the negotiation graph by following the negotiation requirements (i.e., assessment and creation of proposals and coordination rules). The service meets these requirements by manipulating the Xplore primitives [14].

Besides these functionalities, the *Outsrc* service has to interpret and check the negotiation constraints, which are set up in the following two data structures : *Negotiation Object and Negotiation Framework*.

The information provided by the structure of the Negotiation Object on the possible values of the attributes to be negotiated allow easily the *Outsrc* service to check whether the proposals received concern the attributes negotiated in the current negotiation and if they are associated to the values of the intervals specified.

For example, assuming that the Negotiation Object requires that the price should be (*cost <= 10k*), the *Outsrc* service can stop the continuation of the negotiation in the phases associated to the white nodes where the proposals are outside the interval.

Also, by using the *partner* coordination attribute, the *Outsrc* service can make known to the other services the participants imposed by the Negotiation Object or whether other services instantiate this attribute. In this regard, the *Outsrc* service can easily check if the associated value confirms the constraints imposed by the Manager.

At middleware level, the *Outsrc* service has also the function of administrating the transactional aspect of the negotiation. This service is seen like a *coordinator* and has the role to conclude an agreement among the service instances participating in the same negotiation.

Another *Outsrc* service functionality is to interpret and execute the tactics specified in the Negotiation Framework structure by connecting a combination of different instances of the other services.

Thus, the *Outsrc* service as well as the *Insrc* service described below are those connecting the aspects specified at the Negotiation Agent level and their implementation at the coordination services level.

4.1.2. Insrc Service

The *Insrc* service manages the negotiation from the organization side deciding to accept a task proposed in the collaborative networked environment, with some functionalities similar to those of the *Outsrc* service.

The differences come from the fact that this service does not have a complete picture on the negotiation and that, at the beginning of the negotiation, it has no information about what is negotiated or about the constraints of its Manager.

Therefore, looking to the differences, we can say at first that the image of the *Insrc* service on the negotiation graph is limited to the data referring only to its direct negotiation with the *Outsrc* service or with another service negotiating for the organization having initiated the negotiation.

Secondly, unlike the *Outsrc* service, which, from the beginning, has constraints specified by the Manager within the data structures of the *Negotiation Object* and the *Negotiation Framework*, the *Insrc* service has a close interaction with its own Manager on the new aspects required in the negotiation.

Thus, depending on attributes required by the negotiation initiator the *Insrc* service is able to progressively build the data structures describing the Manager's preferences on the negotiation object and on the negotiation process.

4.1.3. Block Service

The *Block* service is used in the negotiations where the task must be executed in its totality by a single participant of the negotiation process. Its main role is to mediate the negotiation among the enterprise that initiated the negotiation and all other enterprises that are invited to the current negotiation. The mediation is performed with the goal of establishing a contract regarding the execution of the whole task by a single participant. In this way, this service is set to manage the constraint of not splitting the subcontracted task in different slots.

An example of the interactions of the Block service is provided by the Figure 5.

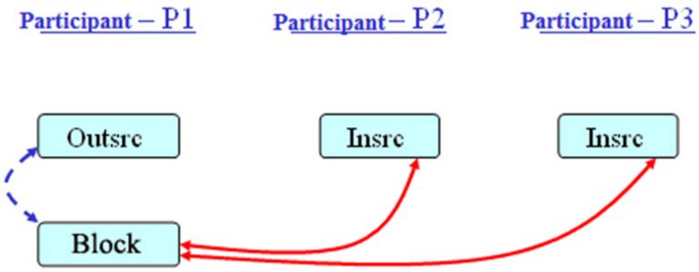

Fig. 5. The interactions of the Block service

It is considered a negotiation among an initiator carpentry workshop (participant P1) and other two guest carpentry workshops (participants P2 and P3). In this case, the negotiation begins by the initialisation of the *Outsrc* service of the participant P1, which invites the *Block* service to the negotiation. Subsequently, *Block* connects to the *Insrc* service of each participant (P2 and P3) and will coordinate simultaneously the bilateral negotiations with them.

As soon as all services are connected, the interaction process among the participants may begin. During this process, the Negotiation Agent of each carpentry workshop involved in the negotiation starts generating and exchanging proposals and counterproposals for the task at hand. The negotiation ends when the participant P1 reaches an agreement with one of the partners (e.g., participant P2) regarding the set of attributes that describe the task being negotiated. At the same time, participant P1 ends the negotiation with P3, this coordination being provided by the *Block* service. It should be noticed that the negotiation may also end without reaching an agreement (e.g., a time limit set for the negotiation has passed or the two partners P2 and P3 are no longer interested in the negotiation).

4.1.4. Split Service

The *Split* service is connected in negotiations in which the possibility of fragmentation of the task in two parts for two different contractors is provided. Its main function is to coordinate the connections between the complete descriptions of the task accomplished by an instance of an *Outsrc* service and the proposals concerning both sides of the task accomplished in two instances of the *Insrc* service.

As soon as the *Split* service is connected, it becomes an intermediary between the *Outsrc* service and the two *Insrc* services. The *Split* service raises some constraints. The constraints on the negotiated task are established by the *Outsrc* service. When one of the *Insrc* services makes a proposal, the *Split* service is able to build the proposal for the second *Insrc* service, so that the task proposed by the *Outsrc* service can be entirely subcontracted. The *Split* service is invited in the negotiation by the *Outsrc* service.

In Figure 6, the implementation of the negotiation for the initiator carpentry workshop (participant P1) is achieved through *Outsrc* and *Split* services. For each of the invited carpentry workshops, the implementation of the negotiation is realized through one of the *Insrc* services.

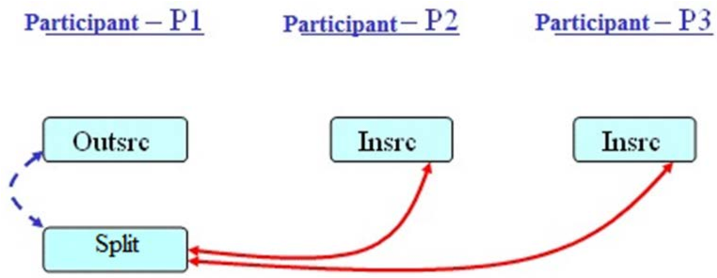

Fig. 6. The interactions of the Split service

Furthermore, as in the first scenario, the two *Insrc* services coordinate only the interactions with the *Outsrc* service of the P1 initiators. Thus, P2 and P3 workshops are not necessarily aware of their entry into the competition and the synchronization among their proposals is made by the *Split* service. The management of the constraints resolution is thus delegated to the *Split* service. This service implements generic mechanisms for constraints solution and ensures the propagation of these constraints.

The negotiation ends at the moment when the carpentry workshop P1 is satisfied with the proposals made by P2 and P3, the difference from the first negotiation residing in the two negotiations ending simultaneously by a single agreement, which will result in two contracts.

As a consequence, for a negotiation among these types of services in a closed environment, the coordination is achieved only through bilateral negotiations that compose the same negotiation. In the next section, we will model the Split service using the negotiation approach proposed in the previous section.

4.2. Example – Modeling the Split Service using Program Formula

It is assumed that for each partner involved in a negotiation there is a negotiation sequence. By using Program Formula, all methods that model the entire negotiation process that must be managed by a certain sequence are defined.

In the following, the behavior of the s_{Split} negotiation sequence with $view(s_{Split}) = (p_1, N, R_{Split})$ will be modeled.

Assuming that the first atom of the negotiation sequence s_{Split} contains initially the following particles: **name**(Id), **start**, **localr**(Rname1,initiated, ∅), the representation particle for *Split* sequence, **firstr**(Rname2,initiated, ∅), the representation particle for *Outsrc* sequence, **count**(X), the particle used to divide the task.

In this scheme we look for the split of the task into two parts, so X=2

For each **clone_create**(Id, New_Id, Msg) event a new atom is created (1.). The second method (2.) generates a new **extr**(Rname, initiated, ∅) representation particle, which represents the image that a sequence of a new participant has on the new negotiation phase. Considering that our aim is to divide the task in two parts, the atoms where we can start negotiation are those containing the **count**(X) particle. Thus, we can obtain two particles of external representation for two new partners.(3.).

(1.) **count**(X) @ **name**(Id) @ **start** @ **clone_create**(Id, New_Id, Msg) @ {X !=0} @{**string_create**(Msg, Rname, Type)} <>- (**start** @ **name**(Id) @ **count**(X)) & (**start** @ **freeze** @ **name**(New_Id) @ **create**(Rname, Type) @ **count**(X))
(2.) **count**(X) @ **freeze** @ **create**(Rname, type) <>- **extr**(Rname, initiated, ∅) @ **count**(--X)
(3.) **count**(0) @ start <>- **enable**

The methods from (4.) to (6.) deal with the exchange of proposals and guarantee dependencies among the proposals made on the execution of the two parts of the task. Method (4.) introduces a new proposal within the system through the **clone_propose** event. The negotiation will develop by taking into account this proposal only on the atoms containing this **enable** control particle.

The modeling of the **propose** particle is different depending on who made the proposals. If the initiator participant (5.) made the proposal, this will refer to the whole task and will be divided by the **construct_split** computational particle in order to build proposals for each invited participant. In case a participant invited in the negotiation makes the proposal, this will be handled through the **solve_split** computational particle in order to build a proposal for the other participant concerning the execution of the remaining part of the task (6).

(4.) **name**(Id)@**enable** @ **clone_propose**(Id, New_ Id, Msg) @{**string_propose**(Msg, Rname, Content)} <>- (**enable** @ **name**(Id)) & (**freeze** @ **name**(New_ Id) @ **propose**(Rname, Content))
(5.) **freeze** @ **localr**(Rname1, St1, I1) @ **firstr**(Rname2, St2, I1) @ **extr**(Rname3, St3, I3)@ **extr**(Rname4, St4, I4)@ **propose**(Rname2, Content) @ {**construct_split**(I1,I3,I4Content,I5,I6,I7)}<>- **enable**@ **localr**(Rname1, undefined, I5) @ **firstr**(Rname2, undefined, I5)@**extr**(Rname3, undefined, I6)@ **extr**(Rname4, undefined, I7)
(6.) **freeze** @ **localr**(Rname1, undefined, I1) @ **firstr**(Rname2, undefined, I1) @ **extr**(Rname3, undefined, I3)@ **extr**(Rname4, undefined, I4)@ **propose**(Rname2, Content) @ {**solve_split**(I1,I3,I4Content,I5,I6,I7)}<>- **enable**@ **localr**(Rname1, undefined, I5) @ **firstr**(Rname2, undefined, I5)@**extr**(Rname3, undefined, I6)@ **extr**(Rname4, undefined, I7)

Methods (7)–(10) model the dependencies regarding the status. In all valid negotiation phases (i.e., those having the control particle **enable**) the negotiation partners may accept the current proposal – method (7). In the event that the two partners reach an agreement, in the newly created atom the representation particles for a single partner will have the status success (8 and 9). A new control particle – **waiting -** was introduced to preserve the negotiation atom only for events of type **clone_accept** (10).

Differing form *Block* services [15], in this example there are two ways of concluding an agreement. In the first case, all four representation particles must be in a *success* (11.) status. In the second case, one can conclude an agreement if one of the external representation particles finds itself in a *success* status, but the concluded agreement refers to the whole task (12.). In both cases, when an agreement is concluded, all other atoms are notified to stop negotiation (the **stop** particle is introduced by the mechanism of broadcasting through all atoms composing the $_{SSplit}$ negotiation sequence.)

(7.) **name**(Id) @ **enable** @ **clone_accept**(Id, New_ Id, Msg) @ { **string_accept**(Msg, Rname)}<>- (**enable** @ **name**(Id)) & (**freeze** @ **name**(New_ Id) @ **accept**(Rname))
(8.) **freeze** @ **localr**(Rname1, St1, I) @ **firstr**(Rname2, St2, I) @ **accept**(Rname2)<>- **localr**(Rname1, success, I) @ **firstr**(Rname2, success, I) @ **waiting**
(9.) **freeze** @ **extr**(Rname3, St3, I) @ **accept**(Rname3)<>- **extr**(Rname3, success, I) @ **waiting**
(10.) **name**(Id) @ **waiting** @ **clone_accept**(Id, New_ Id, Msg) @ { **string_accept**(Msg, Rname)}<>- **name**(Id) @ **freeze** @ **accept**(Rname)
(11.) **localr**(Rname1, success, I) @ **firstr**(Rname2, success, I) @ **extr**(Rname3, success, I3) @ **extr**(Rname4, success, I4) @^**stop** <>- **ready**(I)
(12.) **localr**(Rname1, success, I) @ **firstr**(Rname2, success, I) @ **extr**(Rname3, success, I) @^**stop** <>- **ready**(I)

By (13.) and (14.) methods the **clone_reject** event is processed. Thus, two cases are modeled: firstly, an atom is created following the acceptance of a proposal (atom created by method 9) and, secondly, an atom is created following a new proposal (atom created by method 4).

(13.) **name**(Id) @ **waiting** @ **clone_reject**(Id, New_ Id, Msg) @ { **string_reject**(Msg, Rname)}<>**- freeze** @ **name**(New_ Id) @ **reject**(Rname)
(14.) **name**(Id) @ **enable** @ **clone_reject**(Id, New_ Id, Msg) @ { **string_reject**(Msg, Rname)}<>**- freeze** @ **name**(New_ Id) @ **reject**(Rname)

The processing of the **reject** type message is done according to the partner who decides to decline a proposal. If one of the invited participants decides to stop the negotiation in the current atom, this will be visible in the atom managed by the $_{SSplit}$ sequence only at the level of the representation particle of the participant who sent the rejection.(15.). If the initiator participant sent the refusal, the negotiation atom is completely dissolved (16.). Similarly, the negotiation stops in the atoms where the two participants are invited in a *failure* (17.) status and in the atoms containing the **stop** (18.) particle.

(15.) **freeze** @ **extr**(Rname3, St3, I) @ **reject**(Rname3) <>**- extr**(Rname3, failure, I)
(16.) **freeze** @ **localr**(Rname1, St1, I) @ **firstr**(Rname2, St2, I) @ **reject**(Rname2) <>**-** #t
(17.) **extr**(Rname3, failure, I3) @ **extr**(Rname4, failure, I4) <>**-** #**t**

stop <>**-** #t

5. Final Considerations

This paper proposes a framework for modeling and managing parallel and concurrent negotiations. The business-to-business interaction context in which our negotiations take place forces us to model the unexpected and the dynamic aspects of this environment. An organization may participate in several parallel negotiations. Each negotiation may end with the acceptance of a contract that will automatically reduce the available resources and it will modify the context for the remaining negotiations. We have modeled this dynamic evolution of the context using IAMs metaphor that allows us to limit the acceptance of a negotiation to the available set of resources.

In the current work we have described in our negotiation framework only the interactions with the goal to outsource or insource a task. A negotiation process may end with a contract and in that case the supply schedule management and the well going of the contracted task are both parts of the outsourcing process. In the sequence of our research we will complete out framework with the contract management process and a possible renegotiation mechanism.

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Online dissemination of news in Nicolae Titulescu University

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Abstract

"Traditional" websites are a very good method of disseminating information for students in online environment. We might thing that with this new trend, people prefer to get information on a social network website, but actually for complex information the "traditional" websites are better.

Facebook social network is very used in Romania, mostly by young people. It is a common saying around here: if you do not have a Facebook account, then you do not exist. The Facebook account of the University was created in may, 2012. Since then it has been a powerful tool for disseminating information, but mostly for photos, short messages, links and videos.

YouTube and Twitter are not that used by students for finding information about their University, but during one year, I've recorded growth in number of followers.

In this paper I compare these four online methods of disseminating information for students (may 2012-may 2013 period of time).

Keywords: News, Website, Social Networks, Traffic.

1. Introduction

For students in a University easy access to information is critical. Methods of disseminating information for students are through the University websites, forums or more popular now for students through social network websites.

Nicolae Titulescu University has a main website (www.univnt.ro) and many sub domains such as erasmus.univnt.ro (a website for ERASMUS program), cks.univnt.ro (a website for a scientifically conference) and other. It also has a forum, where students and others can talk and from some time now, it has social accounts like: Facebook; YouTube and Twitter.

Nicolae Titulescu University is very active in the online environment, posting new content and updating information on all websites. This is highly appreciated by students who have easy access through Internet to information. In order to keep in touch with students even more, the University is also present on social networks with daily updates and content of interest for students.

Social networks are a popular method for disseminating information to students [1], but a website can be better organized and information is easier to find. For example, on a social network is not so good to write long information, long text, because people want to read and see something fast there. Social networks are the best for sharing photos or videos.

By "traditional" websites, I understand the websites that are not based on a social network, sites that contain information and data and are free to access and read.

In this paper I analyze how students receive information and how they react to it. For monitoring the websites and the forum traffic, I used a software tool that generates advanced web, streaming, ftp or mail server statistics, graphically. For the social networks I gathered the date directly from the websites.

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2. Analysis of the methods and their results

2.1. Website – www.univnt.ro

The most powerful tool for disseminating information remains a website, even though social networks are gaining more and more people every day. This is determined by the high number of unique visitors and number of visits.

From the data gathered between august 2012 and may 2013, we can see that the number of unique visitors and the number of visits are lower only during summer break, but even then they still remain high comparing to the number of people that follow the University on social networks.

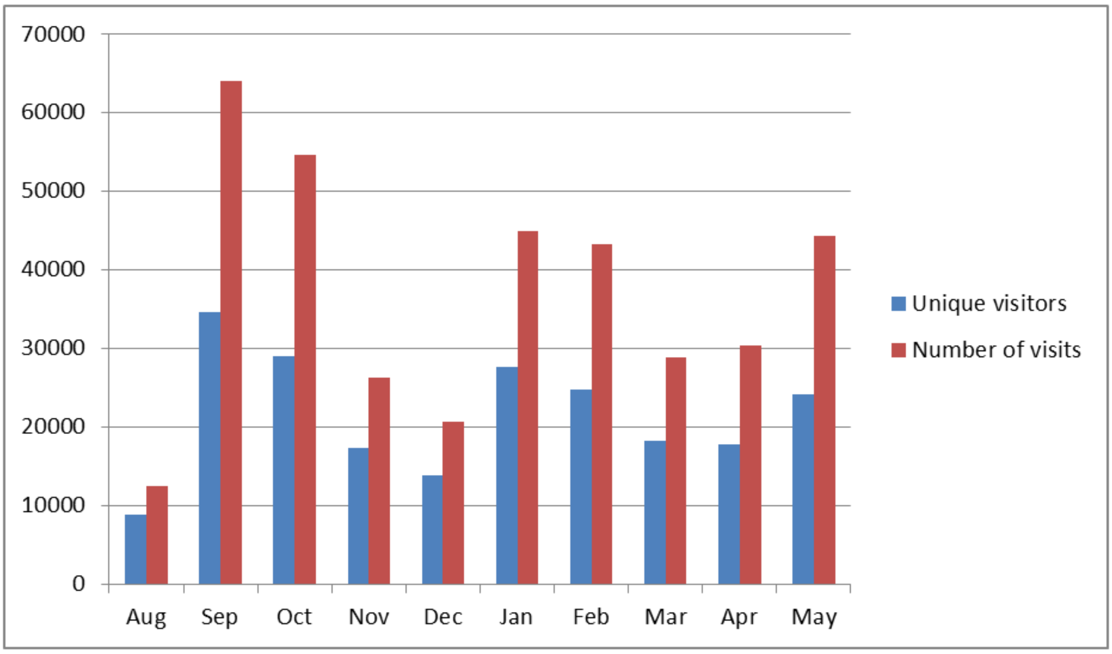

Fig. 1. August 2012 to May 2013

In figure 1, it can be observed that in September and October there is a very high traffic on the website. That is because a new academic year begins and everybody is visiting the website to get all the new information.

During the academic year, growth can be seen in the number of unique visitors and the number of visits in the exams period.

People visit the website to get information and updates. The University continuously updates and adds information on the website, so students can find information about timetables, exams, teaching staff and a lot others.

The website has an area only for news. Most of the news posted here can also be found on our social networks. In figure 2, it can be seen how many times the news section of the website has been viewed.

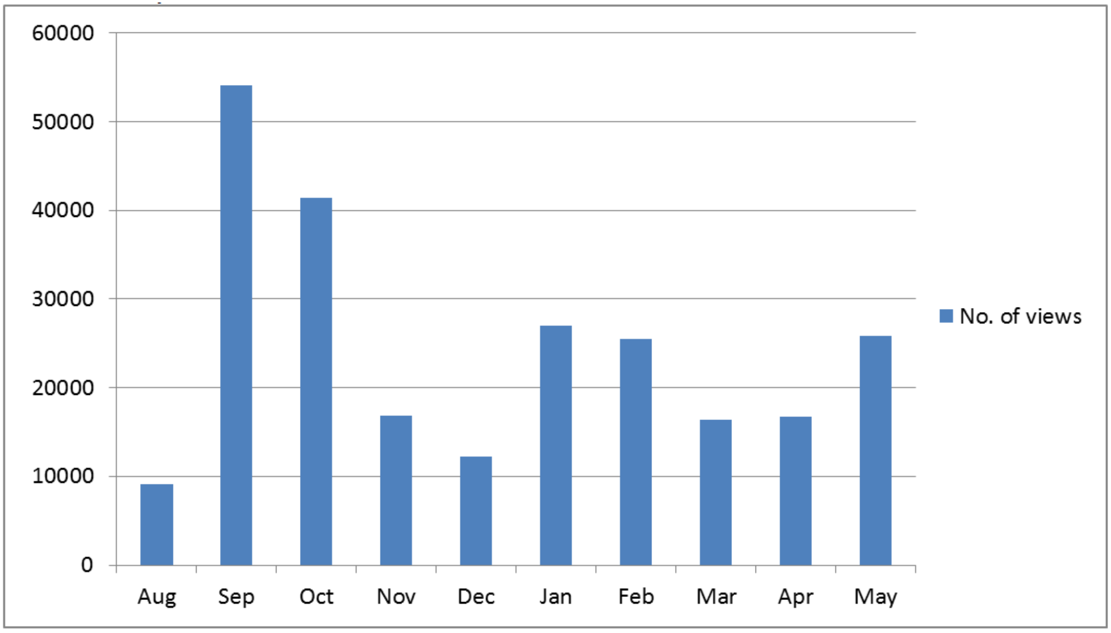

Fig. 2. News section in website univnt.ro

Comparing data from figure 1 and figure 2, it can be observed that most of the people that visit the website, also check the news area.

From the data collected it can be concluded that a website remains very visited and important. There is a high traffic on the website, this means that the students are interested in finding information, but also that the information on the website is valuable.

2.2. Forum – forum.univnt.ro

Although forums are losing ground to social networks and they become less popular, significant traffic is recorded on them.

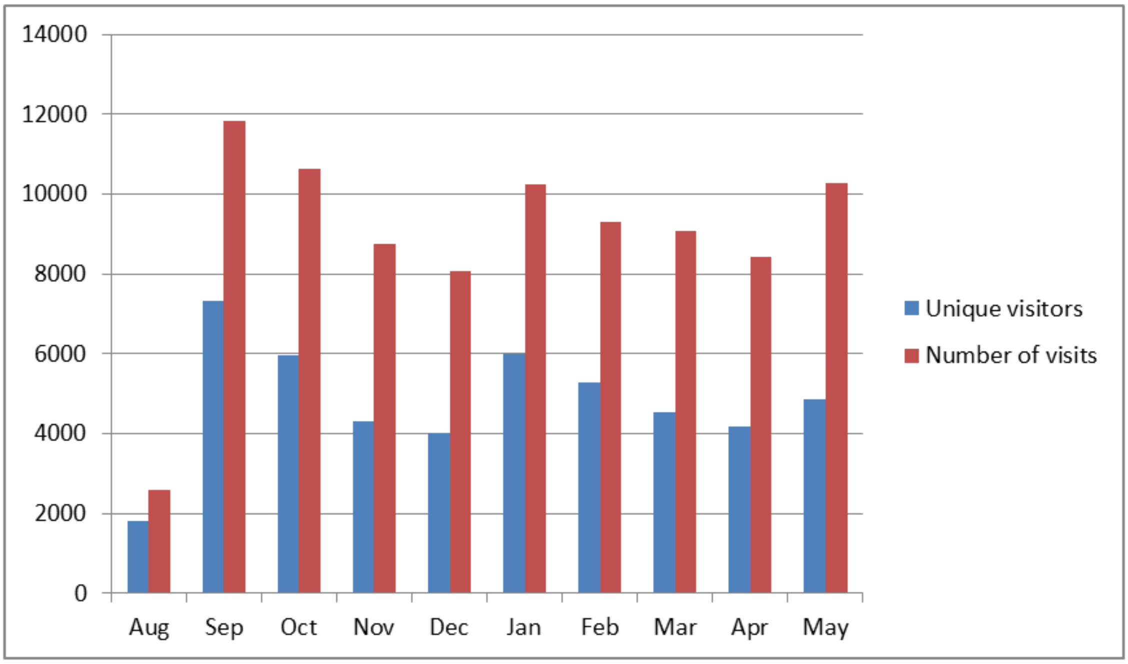

Fig. 3. August 2012 to May 2013 traffic on forum.univnt.ro

Usually people (students) use the forum to exchange information between one and another. The number of visitors and visits is significantly lower on the forum than on the website.

In my opinion, people will continue to move to social networks and use forums less. Comparing traffic between the website and the forum, it can be observed that the forums traffic is not even half of the websites traffic, but still people check the forum and exchange opinions on it.

An average of almost 5000 unique visitors per month is a high number and it is comparable to the Facebook account traffic.

2.3. Facebook

A new method of disseminating information is Facebook and it has a educational use [2]. Nicolae Titulescu University's Facebook account currently (may 2013) has 1,488 likes. This means that at least 1,488 people check the page on a regular basis and receive news and notifications on their wall page.

From the fact that the most viewed post of our page has a reach of 3,082 people (the number of unique people who have seen our post), we can conclude that not everyone that checks the University Facebook page has also clicked the "Like" button, so the University actually has more fans than "likes".

The account is mostly used to share important information about different activities in the University, such as conferences, meetings or opened lessons, but also for sharing information about exams schedule, admission in the University, new learning programs and many more.

Every time content is shared on the Facebook page, almost immediately reactions from the students appear. They press the like button, or they comment and sometimes they even share the content. This means that the interest is real.

Analyzing the gender of the people that liked the University Facebook page, it can be noticed that almost 70% of users are females.

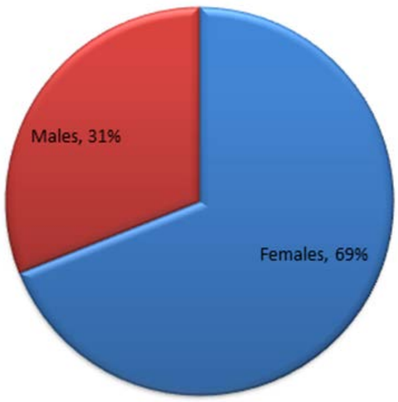

Fig. 4. Gender

Also, the age interval 18-24 is represented by almost 75% of people. The age interval 25-34 is the next most represented by almost 20% of people. So from this it can be concluded that most of the people that liked and follow the University Facebook page are actual students or recently former students. This is normal for an University page.

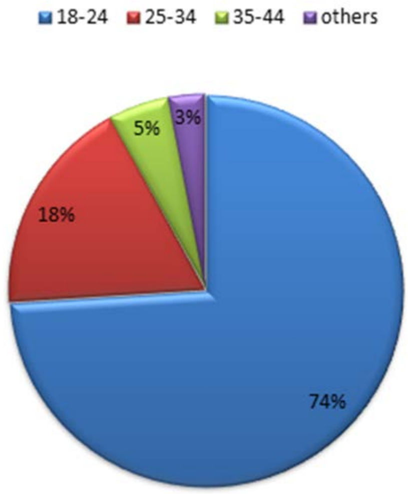

Fig. 5. Age

Most of the people that liked the University page are Romanians, that is because most of our students are Romanian and also the content is mainly in Romanian language. Due to International Scientifically Conferences and former students that currently live abroad, the University has a few followers from countries like Spain, Italy or Germany.

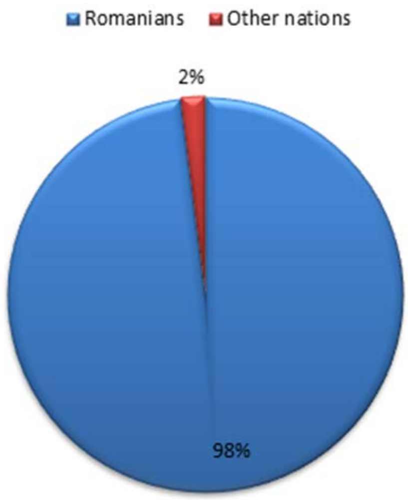

Fig. 6. Country

Even though the University promotes the Facebook account on external web pages and in the University, just a small percent of the people come from external sources, like Google search engine, the University web page: www.univnt.ro. Most of the people just search the University directly in Facebook or see the content on other people wall pages and click on that content, not using the direct link.

The University has currently 70 albums with photos of interest for the students. We can find photos from conferences, contests, workshops, library, seminars, different sports activities and others, all related to the University. These photos are public and everybody can see them, even if they do not have a Facebook account. I’ve noticed that most people have secured their Facebook profiles, so that their content is not public and they keep it just for their friends. This type of behavior, from the students, can be found also on the University Facebook account because there are not many tags in the pictures with the students, even though students press the like button on those photos, that is because once you tag yourself in a public photo, everyone can see your name in that photo and your privacy will be gone.

The University does not post videos directly on the Facebook account. It prefers to post them on the YouTube channel and then share the link on the Facebook page.

Getting more likes for the page is a way to see that students and not just them are interested in the content posted on the page. It has become clear that if you just have a page and you do not post content daily, than the interest from the students drops.

The first 500 likes were reached in September 19, 2012. Then 1000 likes were reached in November 27, 2012. Since then the University receives a couple of likes per day.

There are three types of methods to reach people on Facebook: organic, paid or viral. The organic number of people that were reached is determined by the number of unique people that saw the content on their news feed or came directly on the page (this includes people that liked the page or not). The paid number is determined by the number of unique people that saw an ad or sponsored story on Facebook. Nicolae Titulescu has never used, yet, the paid method to reach people. The viral number is determined by the number of unique people that saw content from the University in stories published by one of their friends. Stories include liking the page, posting on the University wall, commenting on a photo, tagging in a photo and other. Nicolae Titulescu has reached people mostly by the viral method.

3. The main ways and benefits of using Facebook in education

- information asking: students can ask for information on Facebook. They can ask the University directly or they can share information with each other. The University has more than 30 opened private threads of discussions with students. Also information is continuously shared directly on the page.

- materials sharing: students can get different materials for studying, posted by the University or they can share them on the University page;

- events: students can see the Upcoming Events in the University. The events option in Facebook is a powerful tool for disseminating information. Students can talk directly in the event Facebook page, they can choose an option that tells the University if they are going to the event or if they are considering it and many more options;

- promote books and articles: the University can promote a book or an article that might be useful to students. During the existence of the Facebook account, several books were promoted on the page;

- organize contests: the University can organize directly on the page different contests. On the University Facebook page are often organized contests with prizes;

- find more about students: the University can ask students what they like, what they do not like. [3]

Other benefits of using Facebook in education are:

- is a free collaborative learning tool where students can offer feedback to the University;

- it offers easy access to photos, posts, videos for students and other people. There materials are hosted by Facebook, so the costs for computer hardware for the University is zero.

Also, Facebook can be an excellent tool for future possible students. They can visit the University page in order to see what is like in the University.

Comparing Facebook social network to the University website and forum, the traffic is lighter, but on Facebook students tend to post and share opinions more often. They also talk to each other directly on the University Facebook page.

4. Other social networks and websites

Nicolae Titulescu University currently tries to disseminate information also on Twitter and YouTube, but these pages have a little less activity than the Facebook page.

On the YouTube account, about 20 videos can be found with a total of 1800 views and 17 followers. For 20 videos, 1800 views is a good number, considering that the content is from the University and academic.

On the Twitter account, 31 tweets of the University can be found and 13 followers, but this is also because Twitter is not that used in Romania as in other countries. So, YouTube and Twitter are still in an incipient state, but they are of value.

5. Conclusions

Information about the University, about activities and others related to the student life is important to students.

A “traditional” website is the most powerful tool for disseminating complex information. In a University with about 4500 students, the recorded traffic is more than good.

Facebook social account is a powerful tool for disseminating information. Universities must adapt to this type of communication with the students. A Facebook account brings more interaction with students and faster access to information. Nicolae Titulescu University is present on this social network and connects with the students. Only due to daily maintenance and updates, the Facebook page is followed by students. Facebook is a great tool for disseminating photos, videos and short news.

A major difference between posting on Facebook and posting on a website is that the Facebook post appears on the News Feed page of people that clicked the like button. On a regular website, like the University website (www.univnt.ro), people must check periodically and see if there are new information, because a notification area does not exist.

A “traditional” website and social networks, in my opinion, complete each other. Each one has it’s purpose.

In conclusion, online dissemination of news must be continuously done through all the methods that are accesible to students.

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Internet of Persons and Things inspired on Brain Models and Neurophysiology

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Abstract

Living in the twenty first century and being part of a modern society entails being entirely acquainted with the Internet. Business success, research and study rely on intense usage of the Internet, doing most of the activities based on information gathered at the Internet and using diverse kind of services available. The recent development in devices and services, either for computational or mobile operations, has revealed a diversity of paths for the Internet to have impact in our lives, either professional or personal. Without notice, every activity we do is becoming somehow connected to the web in multiple forms that can range from the search of information, the communication between people and information storage at the cloud. Everything seems to be so useful and so destined to promote our life and supply our needs for work, learning or recreation activities. As for the social aspects, Internet has a multitude of opportunities to communicate, to share ideas and to get feedback or news, as it happens, with online newspapers, the blogosphere and social networks. With this pervasive and sometimes implicit integration of the Internet in our lives, we are migrating from traditional way of life to an Internet supported lifestyle with many daily Internet based activities executed by each human being. However, despite this movement of almost putting us in the innards of Internet, we didn't yet notice a structural change in such infrastructure to cope with our human nature and, in particular, with the way we perceive and feel the world. This article exposes the vision of the authors for a possible shift in Internet paradigms towards effective support of the human nature.

Keywords: Internet of Things, Neurophysiology, Brain models.

1. Introduction

The success of an enterprise, a given project or even a person, depends on knowledge bases, on the ability to retrieve relevant knowledge and ultimately on how to handle that knowledge towards effective decisions, wise management and thus successful outcomes.

It is noticeable that the technological advances in the last years established a close relationship between humans and devices. Intentionally the word device is so generic that covers technological advancements in so many areas as we can find in our daily activities, either professional, or personal.

The development of many industrial branches devoted to lifestyle consumer, supported by enthusiastic scientific research, has flooded the market with products directed, especially, to younger people or active professionals.

In parallel, and supported by physical devices, Internet is everywhere for every purpose, with an exponential growth of users, along with all kinds of applications, that made Internet an unavoidable tool, an asset for business, research and social life.

The wide usage of Internet in different regions, by different cultures, covers almost every aspect of human life. This may lead to the idea that a good level of interoperability exists between humans and Internet.

However, even a superficial observation, trying to identify the similarities of Internet content and that of the human brain, confirms that there are yet no parallels between the acquisition and support for sensorial and emotional information from both sides.

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It differs in obvious aspects, as it appends with devices and sensorial organs, or between neurophysiology and electronic circuitry. It also differs in the way computers and the brain acquires, stores and handles information. All differences, that makes them two worlds apart.

Above all, we notice that, in what regards to information retrieval, at the Internet we find images, movies and sound. In contrast, we perceive the world with our rich sensorial experience that, in its essence, comprehends five senses plus a multitude of variants over those primary five.

Looking from another angle, our life is mediated by emotions; they determine our decisions and our relations with the others and with events places and objects. It is noticeable that at the Internet there are no infrastructures no services and no data model to support those human aspects.

Finally, we understand that the Internet addresses poorly the needs of humans as its architecture reflects only a technological support for communication and storage of information and knowledge. Oddly the Internet is for human usage, and in many cases it works like a business or a social network. Besides those facts, it lack of interoperability with major human features, as the ability to sense and feel emotions.

Humans need emotions. Humans feel with their senses, their body and their minds and it is curious that surfing the Internet or many online activities are widely viewed as a global high tech adventure and, therefore, could be considered a form of sensation seeking [1].

The present research seeks to understand what can be changed in the interaction with the Internet, explicitly in what regards to handling sensorial and emotional information. It aims to open channels to improve interoperability between the Internet and our nature, which is based in the Human Brain and its neurophysiological setup.

This article starts by making, in section 2, a rational about Internet and what we need and what is the challenge for our usage of the Internet. Then in section 3 an exploration is made on human neurophysiology and in a selected model of the brain. In order to cope with the proposed challenges, a new Data Model is proposed, in section 4, to cope with sensorial and emotional data. A new Architecture based on the lessons learn from the brain is proposed in section 5. Then in section 6, an exploration research path leads from conventional Internet to the proposed human oriented Internet of Things, which also results in a new type of search engine that includes sensorial and emotional information. Finally we draw conclusions on section 7, with the lessons learned and potential uses for the new paradigm of information retrieval and object representation and its benefits for people and business.

2. New perspectives of the Internet

The need of accurate information, at the right time, has assumed a vital role in citizens' daily life. The power of information is such that most of decisions made in different sectors like science and technology, economics, and business development will be based on information that has been generated electronically.

Information has become a key asset of an organization for its' progress [2]. In order to provide key information according to the needs of organizations and citizens, knowledge management frameworks where established to supply that permanent hunger for information.

By so many remarkable specificities, internet has become the most popular source of information [3] and it means that improvements in information management can have an interesting impact, case we reshape information handling over the internet. Internet is used for many proposes from gaming to communication and these days so much on social networking and many other applications. But as for subjects like data handling, information deliverance or knowledge production we need to deal with files, symbols, webpages, in a word, objects.

We tried to understand how persons handle information, by means of the web, and how human neurophysiology and neuropsychology could be used as models for new ways of handling information and knowledge at the Internet. In trying to learn from the brain, research seeks for a strategy that goes beyond conventional information, which is based, mostly in images or text, sounds and movies.

We want a new perspective towards a more humanlike approach with new paths to get information and also new ways of handling information and knowledge by learning with brain's behaviours and in general with neurophysiology. The research results aim to determine if a better characterization of source objects will allow more accurate searches and thus reduce misleading queries for the information we seek.

People should be able to reach information without the need to loose endless time in crawling over never-ending items just by the fact that they have a given keyword, even if that is completely out of the required context [4]. It means that improvements in information management can have an interesting impact in our interactions with Internet contents and services and will impact in the way we connect with others in our social online communities.

In our technological society, changes are needed and an ever-changing pace of novelty will bring new sights and new contents. But we could question about our abilities to reinvent the ways of dealing with information and knowledge over the Internet.

It could be confusing to mention information and knowledge in the same context but the level of interaction varies with business cases or social interaction. The fact that we hardly handle data and that barely we can have a pattern of knowledge and wisdom accessible over the Internet makes information the broader term for our regular experience using the Internet. It is in fact a term of wider spectrum and most general coverture that is why we need to use it when we would like to mostly use knowledge and wisdom.

In matters like data handling, information deliverance or knowledge production we need to deal with files, symbols, text and pictures, in a word, objects. And thus we selected those diverse objects as target for our research.

All these observations can be summarised in; we are using the Internet for multiple purposes and the way we use it does not match human nature; we are probably loosing too much time with misleading search results; there are examples from neurophysiology and neuropsychology that can be used as use cases with expected benefit for human computer interactions and for better serve the human proposes.

Then the challenges are, first; the need for a better Interoperability between our nature, our brain and our neurophysiology and the Internet infrastructure, and secondly; to improve data acquisition and knowledge management based on lessons learned from our neurophysiology and from selected models of our brain.

3. Learning from the Brain

A model of the brain that is largely accepted will be taken as an example to develop new concepts for object representation and knowledge management at the Internet. In particular, from previous studies carried by the authors [4][5], it is described what lessons could be taken that will inspire the design a framework for knowledge management and also new data models for the same purpose. We will explain how this solution is achieved using sensorial information as a driver for we will increase the probability of finding the desired knowledge and reduce the time spent to find that desired knowledge.

We then define the basilar premises for our proposal by defining a knowledge representation that copes with emotional and sensorial information as it happens ad the brain. With this conceptualization in mind we will extend the sensorial information to the five senses, or at least enable that potential and, when possible, associate emotions as they would be textually expressed or device captured, but this all comes from learning with existing information about the brain and our sensorial capacities, as described next.

Recent developments in technical instrumentation in the last century supported by skilled professionals have revealed much information about the physiology of the brain, many new theories giving ground to new theories for the brain functionalities and for human physiology in general.

The most antique execution of electroencephalography (EEG) revealed that brain activity was triggered by external stimuli; in particular it was observed that the input gathered from the eyes would mainly activate the occipital cortex [6]. , Magnetic Resonance Imaging (MRI) studies along with its functional variation (fMRI) have demonstrated the location of the visual cortex and where does the visual stimuli produce effect at the brain in comparison with the location of other stimuli [7].

All that equipment is able to generate physiological data either by image or electrical signals, which researchers can analyse and theorise. However, no matter how impressive the amount of data acquired by all those devices can be, in some perspective, it remains deceiving, as there is no general theory of the brain and no universal model, even knowing that people's brain has the same physiology.

Our work consists, not in developing brain theories, but in picking selected models in this field and try to apply them to knowledge information systems. In this scope the Two-Stream Hypothesis gives us clues about how brain processes visual information. As mentioned before, on the Internet everything is mostly visual.

We receive images that are formed in the occipital region of the brain [8], then according to the Two-Stream Theory, the Dorsal Stream goes from the occipital lobe to the temporal lobe and is known as the "what stream". The Ventral Stream goes from the occipital lobe to the temporal lobe and is known as the "where stream"[9]. The dorsal stream will provide the identification of what are the objects in sight by comparing them with existing memories of objects and shapes from the past. The ventral stream will put that object in context as where that object is placed in a given place or scenario.

Both streams interact as the context will contribute to the possible identifications of the object and the nature of the objects imposes limits to possible contexts.

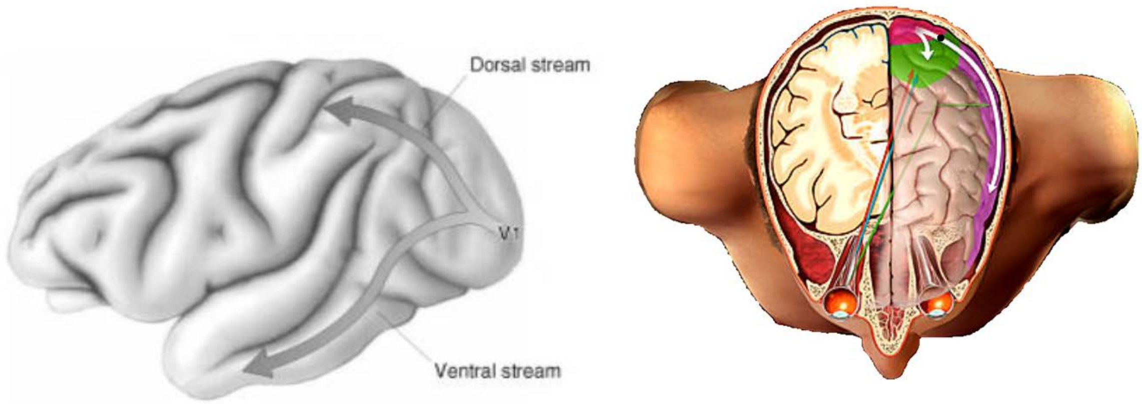

Fig. 1. Image forming in the Occipital Region of the Brain originating the two streams, Ventral and Dorsal.

There are two relevant findings in this theory; first we notice that a visual stimulus is a trigger for actions performed by the brain in trying to give meaning to what is seen and where it fits in real world. Then in following this two main directions, ventral and dorsal, it tries to give meaning to what is seen mostly by comparing with memories or known records of previous sensorial and emotional experience.

This process is composed of the analysis from visual image but then other associations are evoked as in the brain smell, sound, taste and touch are clustered in our memories. Also it is important to notice that emotions are part of the regulation of the process of acquiring information but also regulator of the retrieval process.

In summary the brain stores sensorial information along with emotions, establishing a network of connections that can be invoked by any of those instances of emotions and sensations. And that is the area where, from our research strategy, technology meets the brain.

The neurophysiological analysis and the functional view of the brain must be supported, by the computational side, by a number of tools that can be used to organize knowledge related to the different types of sensorial information plus the emotional data. In order to make it possible it is necessary the design and conception of an ontology that supports the new knowledge base instantiation composed by emotional and sensorial description.

Finally we face the fact that so far the Internet doesn't support and doesn't provide contents as needed, with sensorial and emotional information. Thus semantic annotation, either manual or using some automatism, can be used as basis of an early framework conception. As a consequence it can foresee the interoperability with other sources of information, like those retrieved by medical devices, or others, as described in the conclusions section.

The harmonization of different sources is also a necessary step and it can be mediated with existing ontological frameworks like those proposed by the Mentor Methodology [10]. Once established, a resulting ontology can be generalized and that will be the basis of the proposed framework for knowledge management. This baseline ontology will be regularly updated, according to the readiness of new technology to capture physiological data or, meanwhile, updated with user annotation and personal reporting of sensations and emotions.

4. Defining a new Data Model

The level of interaction that a user has with the Internet, either for usage of specific services or to communicate with persons thru the Internet comprises a wide range of activity that are not likely to be typified in patterns. However one characteristic is unavoidable to each and every user of Internet, that is the need to search and to find what we are looking for which is, so far, materialized in the usage of the search engines.

The importance of search engines for finding relevant information become so tremendous as we need to find information for our work and our study and that information is achieved, essentially at the Internet [11] by contrast to until 10 years ago where information could be found mostly in libraries of books with pages in paper. The results of the search of information establish the frontier between what we know and what is at the Internet.

What we are looking for and what we get, what we know and what we will know next are the sum and the result of our search activity and the effectiveness of something as odd as our search criteria and the performance of the search engine.

In general, searching the Internet consists in describing by words what we are looking for. Recently there is the possibility of searching for images similar to a picture, provided to the search engine. But the vast majority of our usage of Internet as an information system is based essentially on text information, even when the results include files, images or other multimedia contents.

The brain has other approaches to store, and later, to seek for information. Clinical researchers and other scientists have pursued ways to understand the brain. Many models have been constructed based on experiments and observation.

For hundreds of years most of the great classical philosophers like Plato, Aristotle, Spinoza, Descartes, Hobbes and Hume, had recognizable theories of emotion [12] and tried to develop cognitive models in order to understand how the mind works. No model is definitive and a permanent search for understanding of the brain is still under way.

The authors want to explore the usage of those lessons learned to knowledge management, taking widely accepted hypothesis. The primary lessons emerge from regarding human sensorial experience of the world and the flows that take us to learning and exploring and essaying how the information systems can be shaped in a similar manner. Then we are challenged to determine the benefit of taking a human centric approach to enrol with selected neurological models and assess its efficiency for knowledge management.

In practical terms we want to migrate from the classical repository made of text and eBooks, sounds, music and movies to the ability for a full acceptance of all human sensorial and physiological experience. That doesn’t mean solely to include smell, taste and touch but to accommodate human related information. Depicted in Fig. 2. is a simplified vision of this process that, ultimately addresses the human physiological reconnaissance of the world.

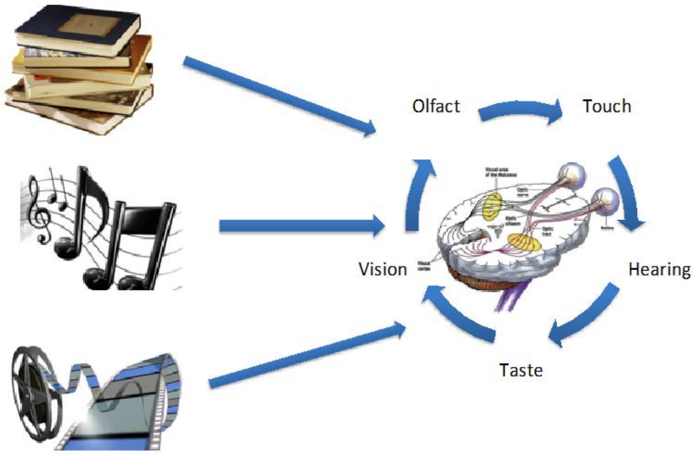

Fig. 2. Shifting Paradigm from 2 senses to a rich sensorial experience

In an IoT context, the same information source can be used to a wider range of applications as it can fit in new kinds of user demands. Enrichment of information will allow a more versatile appliance of available information to different contexts. In a similar way to the sensorial contents, emotional information will make the next step towards a humanized contents and enrolment and clustering of that information towards the needs of persons.

The current research as led to the concept of i-Episode [5] with the clustering of Emotions and Sensations related with the information collected about a person at a given time in a given place.

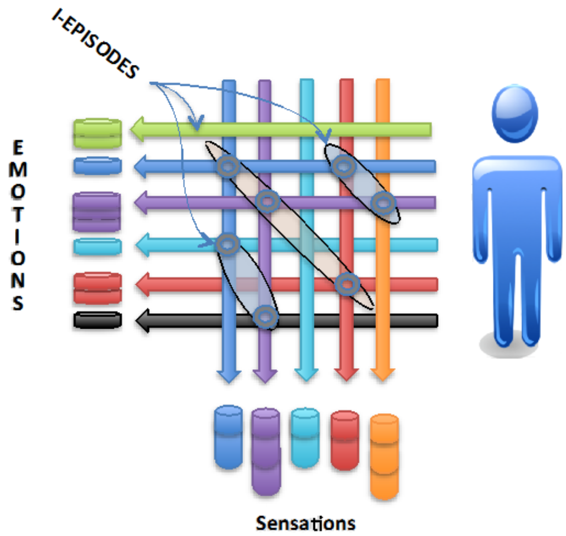

Fig. 3. The concept of I-Episodes as clusters of Sensations and Emotions [5]

The basis for the new framework is the proposed Data Model, which includes the ability to represent emotions and sensations, clustered for each person. Along with the ability to represent sensorial and emotional information for objects, a differentiating feature is the I-Episode that stands for Internet Episode and refers to the ability to represent, at the Internet, sensorial and emotional information for a given person. In what concerns to the I-Episode that that is a temporal gap during which information is collected. Without any specific boundary, it is supposed to collect information in the same moment, or related to the same event, linked and clustered in an I-Episodes.

The information that could be acquired remotely or by portable devices is collected for that given person or could be personally created by her. In practical terms if a person has a smell detector that could deploy the smell of alcohol and even take note of it's molecule, but if not, a person can state that there was an intense smell of alcohol at that site. All that means that this new paradigm has sensorial and emotional data in its basis but is meant to build a DIKW towards Human oriented Wisdom as depicted in Fig. 4.

As there are so many different assumptions about the definitions and differentiations over Data, Information and Knowledge [13] we keep Wisdom as a Human capability and we focus essentially in collecting Data, assuming here raw data from sensors or generated by humans and Information is put at the level of the I-Episodes where some rational is made for the connections between sensations and emotions for a person. As for what concerns Knowledge, in the sense of this sequence DIKW, it is expected to result some Knowledge over the analysis, inference and predictability of sensorial and emotional information for Internet users.

Fig. 4. New data model as base for the path to wisdom

With the concepts described so far and with the identified potential for a renewed data representation at the Internet taking in account the human specificities, it is then opportune to develop the architecture that supports such evolution. It is important to consider the rational of this framework, how the information is related after generated or captured and how it is achieved for further purposes. That is the reason behind the next section where such architecture is proposed.

5. Brain Based Architecture

The departing point for the proposed framework is to take the two-stream hypothesis has a potential model for handling information in innovative and fertile knowledge bases. The objective of the proposed framework is to retrieve sensorial and emotional information creating support for human oriented knowledge bases.

For the establishment of the proposed framework two paths were followed with a common goal towards new and more efficient models for information systems.

The first is by exploiting the retrieval and storage of information in an information System as it happens according to the two-streams hypothesis. This could be backed by semantically-based Web Map Mediation Services, a core of semantic and ontological tools for mapping [14], mediation, annotation and what else found needed for pursuing the most consensual and interoperable solution as possible.

The second, directly related with the first, consists in instantiating a knowledge base and harmonising it with existing information thus providing an ontological solution that includes sensorial and emotional information either by properly instantiate with retrieved knowledge or by semantic annotation of existing knowledge bases. The expected result in terms of construction and contents is a new form of representing information that will permit new acquisition opportunities and empower the existing knowledge. In terms of functionality new services can be deployed making use of sensorial and emotional information along of new opportunities for more ubiquitously searching and finding the desired information.

Comparing to existing solutions, we propose a framework that supports:

1) A new data model that includes sensorial and emotional information along with the usual text and photos.

2) A new approach for searching methodologies, on the Internet, by allowing new specific fields according to the proposed data model

3) A new ontology to facilitate standardization of the new and extended data model. As result from this framework we want to change the established paradigm of Internet object identification and characterization and, that way, supporting disruptive methods for knowledge management.

In view of the operational objectives for this framework in the possibility of storing sensorial and emotional information in our records, even if those are centralized in the conventional storage of pictures. The other objective is to enable the addition of diverse sensorial and emotional information to existing records.

The current research has developed support for the new kinds of information based on ontologies that need to be supported in some reliable infrastructure, as is the cases for the wikis or some other service that allows expansion of data annexed to pictures.

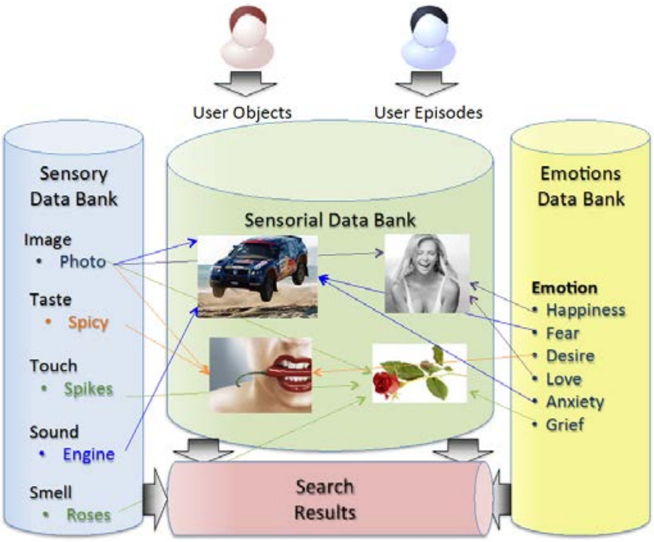

Fig. 5. Proposed Architectural Model

The proposed framework

There are three sequential steps towards the establishment of the proposed framework for knowledge management. In all cases the development of an ontology for emotions and its instantiation will be present and research will be done using the above-mentioned tools and services.

The first step comprises the usage of the existing search engines to feed the new ontology with sensorial and emotional information. That means a different approach to search events with result in retrieving information for ontology instantiation.

The second step consists on using the instantiations as a database for emotions and sensations, thus improving the ontology usage with semantic sensorial and emotional annotation. Finally the third step uses the infrastructure proposed by the previous steps but using sensorial representation and emotional information, this could be done with a new set of devices, some in development others to be deployed by new technological advances. The final step is a domain for future work.

The first stage that is being developed consists in presenting a new data model that includes support for sensorial information. That start-up will be supported by an annotation process that assigns sensorial metadata to an entity, with a link where the semantic annotation refers to ontology content [15].

The definition of the framework implies the creation of capacity to store emotions and sensations for linkage to objects or for describing events. At first emotions need to be described as text but later will be possible to retrieve physiological signs associated with those emotions. As for the sensorial information, there are already formats that describe them without the need for text. The more obvious cases are images and sound, but it is also possible to describe smell and taste by molecular description. Also for tactile experience there are already some trials that is the case for the force- feedback that some games support for providing a better gaming experience.

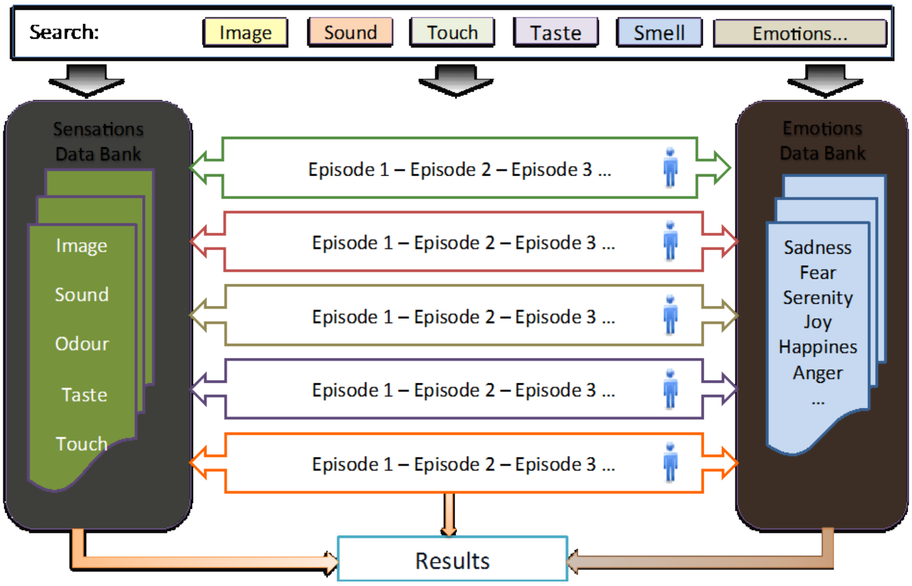

Fig. 6. Framework based on the Five Senses and Emotions

The framework then provides the possibility of searching for the different components of emotions and sensations. The stored contents can also be linked as episodes for each person or exist in atomic format. As with other search engines, the ontology learns with the effectiveness of the searches performed by users in a process of validation and reinforcement.

A template will be the basis of information retrieval and identification and can operate in background by searching for complementary information. At this stage the framework seeks information from the user and tries to associate as much sensorial and emotional information as possible in order to draw a path towards sensorial and emotional knowledge base. In parallel to the search and retrieve events, and as result of that operationalization of the framework results a database of sensorial and emotional information collected and stored for future usage with other objects.

In order to establish a path towards the usage of this framework it is necessary to be able to collect information and then to manage that information according to the model in Fig. 6. These days it is possible to have devices to collect information for personal use or to upload them for specific services on the Internet.

In what regards to sensorial information, the type of devices we use to collect information that are applicable to the framework purposes are photo and movie cameras and also voice recording devices and cell phones. Moreover some new experiments will allow collection of emotional information, as wearable computers that collect physiological measures being those; galvanic skin response, heart rate and temperature [15] this along with studies on recognizing emotions from facial expressions [16]. Plutchik's wheel in Figure 7, represents families of Emotions and it is one of the possible sets that can be used on Ontologies for Emotions.

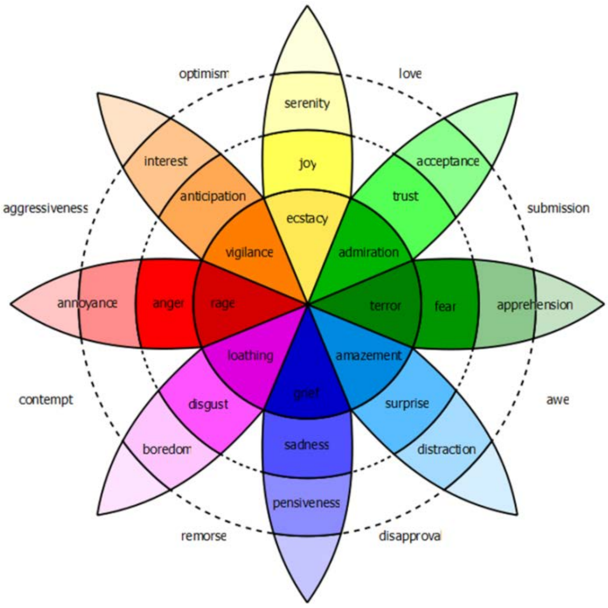

Fig. 7. – Plutchik three-dimensional Circumplex model

In order to use the framework it is necessary to address the question with the technology we have today is to identify emotions with such detail, as Plutchik and others describe, would require many other parameters as blood chemistry, brain activity, neurotransmitters and many other modalities, however recent studies are making significant progress identifying emotions without those specificities [17].

6. Information gathering supported by IoT concepts

The Internet of Things (IoT) concept comes from the notion that today computers, and therefore the Internet, are almost wholly dependent on human beings for information but people have limited time, attention and accuracy, all of which means they are not very good at capturing data about things in the real world [18].

In general terms, Internet of Things proposes an environment littered with communicating objects, with a pervasive presence around us of a variety of things, or objects, such as Radio-Frequency Identification (RFID), tags, sensors, actuators, mobile phones, etc. These networked objects will be visible in both working and domestic fields, with possible scenarios in domotics, assisted living, e-health and enhanced learning as possible examples of this new paradigm with a leading role in a near future. [19].

In order to assist in daily tasks, mobile applications try to acquire most information about a person will be supported, typically, by portable devices. Interesting concepts like smart clothing [20], wearable computers or sensorial applications for mobile phones can be of interest to gather information enriching a person's I-Episodes.

Also with the development of cyber-physical systems (CPS) result a new range of possibilities to interact with the physical world around us [21] where it is possible to collect information that could be available in the environment and not just generated by the subject. This could be one of the interesting issues to explore by enabling data gathering by, for example, a city's measuring devices for temperature, humidity, etc.

Thus in order to advance mobile data acquisition one step ahead, we propose that computational resources meet our biological perception of the world by considering our sensorial capabilities and being able to retrieve and manage all that sensorial information. That means to collect data from our own along with what can be deployed by possible external IoT services.

In a simplified view we could consider that a webpage with climatic data of one place is, in a certain why, an indirect measure of IoT devices in town, those would be for instance, an hygrometer and a thermometer that communicate readings to some service in town hall that publish them on the web.

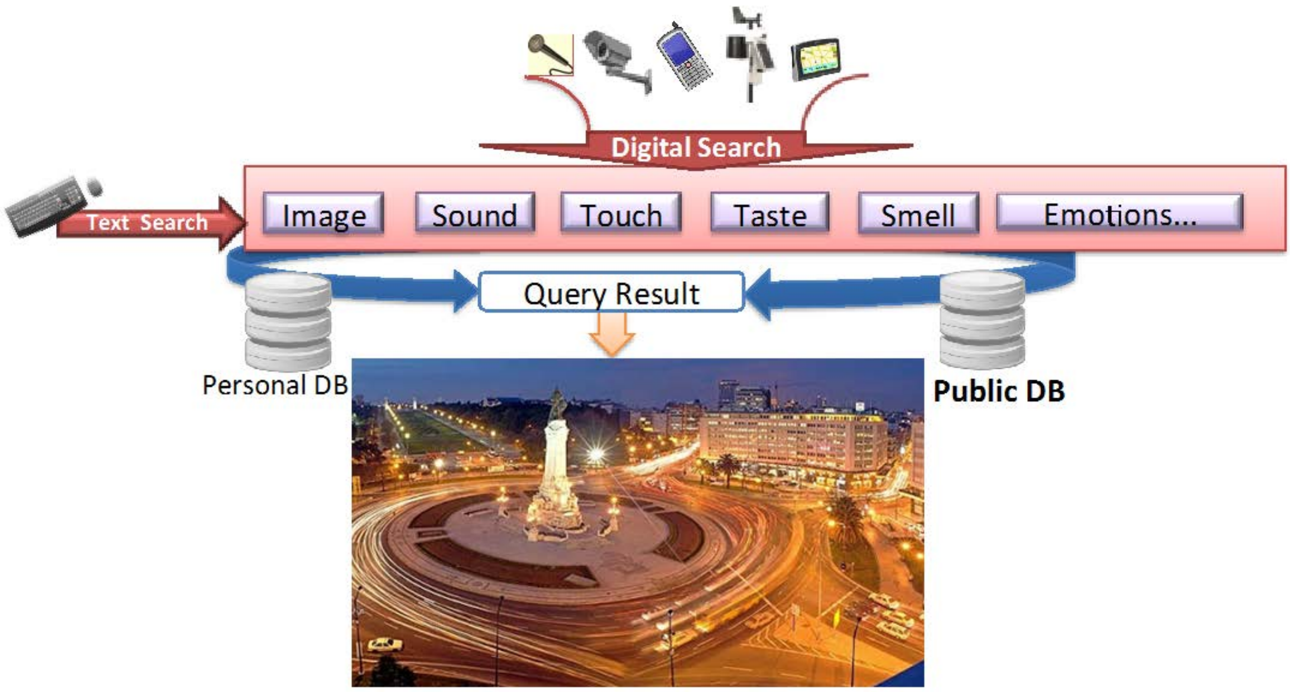

Fig. 8. Automated capture of sensorial information

The proposed view is partly futuristic but that does not imply a long time before it is feasible neither implies that partly it can be done. In fact the futuristic issues here are related to the fact that entities collect information and do not make it available in place, they filter information and sometimes publish partly or average measures per unit of time, sometimes per day or month.

The major challenge would be to retrieve emotional information as that depends on portable measuring devices that are not readily available on our mobile equipment, even thought some mobile phones already capture some measures like the heart rate. Again, as mention in last section there is the emotions issue that although Human emotions have been subject of study, with different approaches by different researchers it was possible to determine in 1981, at least one hundred different definitions [22], with a varying number of definitions by the same author. Then in order to become able to represent emotions on the Internet it is necessary to follow a pragmatic approach.

It would be important to know how many emotions are there. Scherer submits that there is currently no answer to that question [23]. The framework will address that question with the flexibility in the ontology definition in order to cope with further changes in the number of emotions and, taking the advances in technology, to handle new digitally detected emotions.

7. Conclusions and Future Work

The research work carried so far demonstrates the ability to promote the interoperability between people and computer systems, including the Internet environment. For that goal to be achieved it is necessary to converge to similar ways of retrieving and managing information as humans do and has it can be learned from the brain and from our neurophysiology.

That is the highlighted innovation from the proposed framework. Also an important finding is that, in order to understand at what lever we want to interoperate persons and systems, it is important to be able to proceed knowing the existing differences raised by the differences in “hardware” and also by different strategies in managing knowledge.

Regarding that perspective, it is noticeable that hardware compatibility is not an option in the next times, as humans will not become digital and will not integrate chips, in the same way computers will not have cells or nervous system. That leaves us with software, services and in particular, frameworks to handle whatever approach we design.

It is important to notice, however, that developments in Human Computer Interface will promote a better relation between both systems and that could be improved with usage of devices to mediate the interaction, those could be sensors and actuators at device level. Regarding systems level it is important to converge to semantic models that will enable information that can be interpreted and managed both by humans and systems [24].

The resulting framework establishes an advance by deploying a new data model that can be used at the Internet to deal with human physiological measurements and with human centric information clusters. It will foster ground for cope with the information deployed by devices being developed and by the expression of humans regarding emotions and sensations.

As future work, it is foreseen the adaptation of the current framework for selected business, as is the case of the food industry where with the appropriated devices, as some that prototypes that already exist [25], industry can better reach costumers. This would also be extendible to the perfume industry case there is the ability to generate dozens of scents as it is the case for this business.

The authors also consider the benefit of an enriched sensorial experience for disabled people, while navigating the Internet, as is the case for persons with visual disabilities with the opportunity to experience other sensorial experiences.

Finally, the entertainment industry, either for movies or gaming, would benefit with such enriched immersive environments based on emotional data gathering along with sensorial enriched experience, reaching the brain in many ways and completing the sensorial experience towards human nature.

Acknowledgement

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Simulating the binary variates for the components of a socio-economical system

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Abstract

Often in practice the components Wj of a sociological or an economical system $\underline{W}$ take discrete 0-1 values. We talk about how to generate arbitrary observations from a binary 0-1 system $\underline{B}$ when is known the multidimensional distribution of the discrete random vector $\underline{B}$. We also simulated a simplified structure of B given by the marginal distributions together with the matrix of the correlation coefficients. Different properties of the systems $\underline{W}$ are presented too.

Keywords: binary system, marginal distribution, Monte Carlo simulation, random variates, correlation coefficient.

1. Introduction

A general system $\underline{W}$ with k components $W_1, W_2, W_3, \ldots, W_k$ is characterized by the features λ_j of every variable W_j and the intensity c_{ij} of the relation between any two components W_i and W_j, $1 \le i, j \le k$. Frequently in practice the relation among the elements of the subsystem $\{W_i, W_j\}$ is a symmetric one, that is $c_{ij} = c_{ji}$.

The characteristic λ_j of the component W_j could be just the parameters which define the marginal distribution of the random variable W_j. In the following we will choose the Pearson correlation coefficient $Cor(W_i, W_j)$ to measure the intensity c_{ij} of the relation which is present between the components W_i and W_j of the system $\underline{W}$. We mention here that in the literature there are known many other indicators to measure the ratio among the elements W_i and W_j from $\underline{W}$ ([1], [2], [6]).

Figure 1 presents some kinds of systems $\underline{W}$.

Many times in practice the system $\underline{W}$ has components W_j with a normal distribution. Such a system will be designated in the subsequent by $\underline{X}$. For this particular case the system components X_j, $1 \le j \le k$, are dependent normal random variables characterized by their means μ_j and their dispersions σ_j^2. So we will take $\lambda_j = (\mu_j, \sigma_j)$ and $c_{ij} = Cor(X_i, X_j)$, $1 \le i, j \le k$.

Another class from the systems $\underline{W}$ are binary 0-1 systems designated by $\underline{B}$. The elements $B_1, B_2, B_3, \ldots, B_k$ of the system $\underline{B}$ are binary dependent variables which take only the values 0 and 1. To make a distinction between the systems $\underline{B}$ and $\underline{X}$ we will use the notation $r_{ij} = Cor(B_i, B_j)$ in the discrete case and $c_{ij} = Cor(X_i, X_j)$ for the continuous normal marginals variant.

We mention here that the normal type system $\underline{X}$ is completely characterized by the set of the parameters μ_i, σ_i, c_{ij}, $1 \le i < j \le k$, that is $k(k+3)/2$ values ([3]).

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But the multidimensional distribution of an arbitrary binary system $\underline{B}$ has more parameters. For this reason, in opposition with the normal distributions case, we can not define a general binary 0-1 system $\underline{B}$ by knowing only the values μ_i, σ_i, r_{ij}, $1 \le i < j \le k$. More, in the discrete case of $\underline{B}$, the variance $\sigma_j^2 = Var(B_j)$ depends on the mean $\mu_j = Mean(B_j)$. So, knowing only the marginals and the correlation matrix of $\underline{B}$ we lose a lot of information which define the real multivariate discrete distribution of the system $\underline{B}$. Some details concerning the behavior of a binary system $\underline{B}$ will be given in the next section.

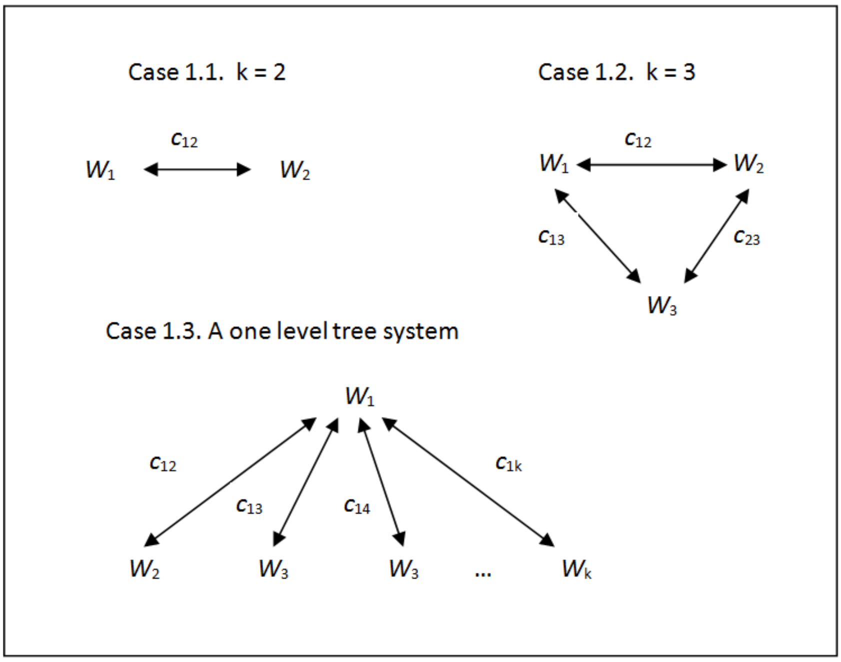


Fig. 1. A system $\underline{W}$ with k components

We reveal a new other aspect which is present for sociological and economical systems too. So, the individuals of a given population estimate the behaviour of each component W_j from a continuous system $\underline{W}$ by putting subjective marks.

In this approach a binary system $\underline{B}$ results from $\underline{W}$ when the marks take only 0 and 1 values. Hence, in practice, we often approximate a continuous system $\underline{W}$ by a binary one, like $\underline{B}$. In this case we must evaluate the discretization error.

2. The binary 0-1 systems

The binary random vector $\underline{B} = (B_1, B_2, B_3, \ldots, B_k)$ which takes only 0 and 1 values is completely characterized by the probabilities $p_{i_1,i_2,i_3,\ldots,i_k}$, $i_j \in \{0,1\}$, $1 \le j \le k$, where

$$p_{i_1,i_2,i_3,\ldots,i_k} = Pr(B_1 = i_1, B_2 = i_2, B_3 = i_3, \ldots, B_k = i_k)$$

Obviously, $p_{i_1,i_2,i_3,\ldots,i_k} \ge 0$ for all indices $i_j \in \{0,1\}$ and in addition

$$\sum_{i_1=0}^{i_1=1} \sum_{i_2=0}^{i_2=1} \sum_{i_3=0}^{i_3=1} \ldots \sum_{i_k=0}^{i_k=1} p_{i_1,i_2,i_3,\ldots,i_k} = 1 \qquad (1)$$

To simplify our expose, for any $i_j \in \{0,1\}$, we will use the notation

$p_{i_1,\dots,i_{j-1},+,i_{j+1},\dots,i_k} = p_{i_1,\dots,i_{j-1},0,i_{j+1},\dots,i_k} + p_{i_1,\dots,i_{j-1},1,i_{j+1},\dots,i_k}$

So, the equality (1) could be also written in a shorter form as $p_{+,+,+,\dots,+} = 1$.

The marginal distributions of the random vector $\underline{B}$ are defined only by the probabilities $q_j = Pr(B_j = 1)$, $1 \le j \le k$.

Choosing, for example, the component B_1 we deduce

$Pr(B_1 = 0) = p_{0,+,+,\dots,+} = 1 - p_{1,+,+,\dots,+} = 1 - Pr(B_1 = 1) = 1 - q_1$

Remark 1. Since the distribution of the system $\underline{B} = (B_1, B_2, B_3, \dots, B_k)$ is determined by the probabilities $p_{i_1,i_2,i_3,\dots,i_k}$ with the restriction (1) we conclude that a general binary 0-1 system $\underline{B}$ with k components is defined by $2^k - 1$ parameters.

Now we will enumerate some properties of a binary $\underline{B} = (B_1, B_2)$ system which has only two components.

We remind that the distribution of an arbitrary 0-1 binary vector $\underline{B} = (B_1, B_2)$ is given by the probabilities $p_{i,j} = Pr(B_1 = i\,, B_2 = j)$ where $i, j \in \{0, 1\}$ and $p_{+,+} = 1$

In this case $q_1 = p_{1,+} = Pr(B_1 = 1)$, $q_2 = p_{+,1} = Pr(B_2 = 1)$, $0 \le q_1, q_2 \le 1$ and therefore

$p_{1,0} = q_1 - p_{1,1}$, $p_{0,1} = q_2 - p_{1,1}$, $p_{0,0} = 1 + p_{1,1} - q_1 - q_2$

Hence we have the inequalities

P2.1. $max\{0\,, q_1 + q_2 - 1\} \le min\{q_1\,, q_2\}$

After a straightforward calculus we obtain the relations

P2.2. $Mean(B_j) = Mean(B_j^2) = q_j$, $Var(B_j) = q_j\,(1 - q_j)$, $j \in \{0, 1\}$

$$r_{12} = Cor(B_1, B_2) = \frac{p_{1,1} - q_1 q_2}{\sqrt{q_1(1-q_1)}\,\sqrt{q_2(1-q_2)}}\,,\quad 0 < q_1, q_2 < 1$$

Remark 2. This expression of the correlation coefficient $r_{12} = Cor(B_1, B_2)$ does not depend on the concrete values of the binary random variables B_1 and B_2. For example, considering $B_1 \in \{a_1\,, b_1\} \ne \{0, 1\}$, $B_2 \in \{a_2\,, b_2\} \ne \{0, 1\}$ we obtain the same value for the indicator r_{12}.

Since $q_1 = p_{1,0} + p_{1,1}$ and $q_2 = p_{0,1} + p_{1,1}$ we prove easily

P2.3. If $p_{1,1} = q_1 q_2$ then we have also the following equalities

$p_{0,1} = (1 - q_1)\,q_2$, $p_{1,0} = q_1\,(1 - q_2)$, $p_{0,0} = (1 - q_1)(1 - q_2)$

From P2.2 and P2.3 it results

P2.4. The binary 0-1 random variables B_1, B_2 are independent if and only if $r_{12} = Cor(B_1, B_2) = 0$.

Remark 3. The property P2.4 is not always true for an arbitrary continuous two component system $\underline{W} = (W_1, W_2)$.

Applying the propositions P2.1 and P2.2 we deduce the inequalities

P2.5. $Cor(B_1, B_2) \ge \dfrac{max\{0\,, q_1 + q_2 - 1\} - q_1 q_2}{\sqrt{q_1(1-q_1)}\,\sqrt{q_2(1-q_2)}}$, $0 < q_1, q_2 < 1$

$$Cor(B_1,B_2) \le \frac{min\{q_1, q_2\} - q_1 q_2}{\sqrt{q_1(1-q_1)}\sqrt{q_2(1-q_2)}}, \; 0 < q_1, q_2 < 1$$

The following properties are particular cases of the proposition P2.5.

P2.6. If $q_1 = q_2$ then $Cor(B_1,B_2) \le 1$

If $q_1 = 1 - q_2$ then $Cor(B_1,B_2) \ge -1$

Using the formulas

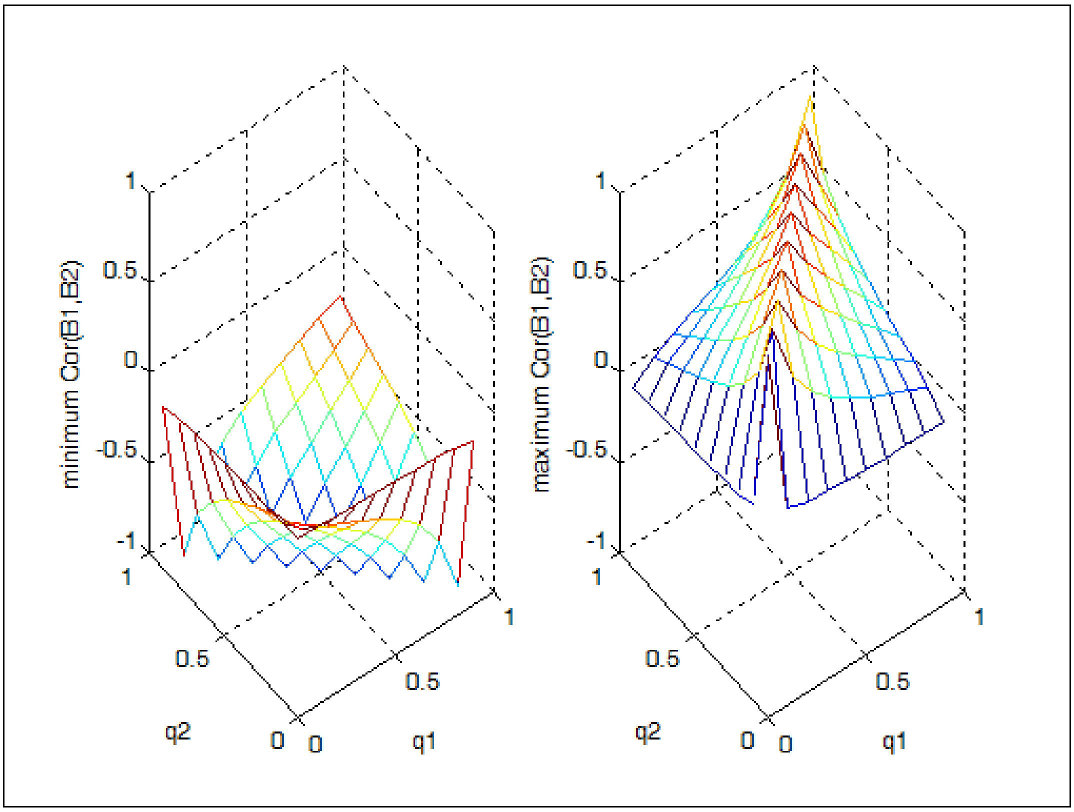
$$Cov(1-B_1, B_2) = -Cov(B_1, B_2), \; Var(1-B_1, B_2) = Var(B_1, B_2)$$

we can prove directly the equalities

P2.7. $Cor(1-B_1, B_2) = Cor(B_1, 1-B_2) = -Cor(B_1, B_2)$

Graphic 1 presents us a suggestive image of the variation for the lower and upper bounds of $r_{12} = Cor(B_1,B_2)$ index depending on the marginal distributions indicators $0 < q_1, q_2 < 1$.

Remark 4. From the propositions P2.1-P2.7 we conclude that the discrete distribution of the system $\underline{B} = (B_1, B_2)$ is completely determined by the indices $0 < q_1, q_2 < 1$ which characterize the marginal distributions of $\underline{B}$ together with the correlation coefficient $r_{12} = Cor(B_1,B_2)$, $-1 \le r_{12} \le 1$. But the parameters q_1, q_2, r_{12} are mutually dependent (see the properties P2.1 and P2.5 or *Graphic 1*).



Graphic 1. The lower and upper bounds of $r_{12} = Cor(B_1,B_2)$

3. Generate random observations from a binary system

Leisch, Weingessel and Hornik suggested in [5] the application of the general inverse method for discrete random vectors ([3], [4]) to generate arbitrary observations $(b_1, b_2, b_3, \ldots, b_k)$, $b_j \in \{0, 1\}$, for the system $\underline{B} = (B_1, B_2, B_3, \ldots, B_k)$.

The following algorithm *GDRV* produces $(b_1, b_2, b_3, \ldots, b_k)$ vectors, $b_j \in \{0, 1\}$, such that

$$Pr(B_1 = b_1, B_2 = b_2, B_3 = b_3, \ldots, B_k = b_k) = p_{b_1, b_2, b_3, \ldots, b_k}$$

where the probabilities $p_{i_1, i_2, i_3, \ldots, i_k}$, $i_j \in \{0, 1\}$, $1 \le j \le k$, define the binary 0-1 system $\underline{B}$.

Algorithm GDRV (Generating Discrete Random Vectors).

Step 0. Input : the probabilities $p_{i_1, i_2, i_3, \ldots, i_k}$, $i_j \in \{0, 1\}$, $1 \le j \le k$, with $p_{+,+,+,\ldots,+} = 1$.

Step 1. Establish a one to function $h : \{1, 2, 3, \ldots, 2^k\} \to \{0, 1\}^k$

Step 2. Compute recurrently the sums

$$s_0 = 0$$

$$s_t = s_{t-1} + p_{h(t)}, \quad 1 \le t \le 2^k$$

Step 3. Generate a random variate u uniformly distributed on the interval $(0, 1]$

Step 4. Find the index $1 \le t \le 2^k$ such that $u \in (s_{t-1}, s_t]$

Step 5. $b = h(t)$

Step 6. Output : b

Details regarding the theoretical justification of the generating procedure *GDRV* can be found in the books [3] and [4].

Remark 5. Applying algorithm *GDRV* we generated $n = 10^6$ random variates (b_1, b_2, b_3) from the binary system $\underline{B} = (B_1, B_2, B_3)$ defined by *Table 1*. For this case the frequences of the categories (i_1, i_2, i_3), $i_j \in \{0, 1\}$, $1 \le j \le 3$, are given in *Table 2*. The validity of the algorithm *GDRV* is proved in part since the theoretical values and the empirical estimations of the probabilities p_{i_1, i_2, i_3} are very closed (compare the results from *Tables 1-2*).

Table 1. The theoretical distribution of the binary 0-1 system $\underline{B} = (B_1, B_2, B_3)$

$p_{0,0,0}$	$p_{0,0,1}$	$p_{0,1,0}$	$p_{0,1,1}$	$p_{1,0,0}$	$p_{1,0,1}$	$p_{1,1,0}$	$p_{1.1.1}$
0.050	0.200	0.100	0.150	0.100	0.050	0.050	0.300

Table 2. The frequences for the variates (b_1, b_2, b_3) ***obtained after*** 10^6 ***simulations with algorithm GDRV***

(0,0,0)	(0,0,1)	(0,1,0)	(0,1,1)	(1,0,0)	(1,0,1)	(1,1,0)	(1,1,1)
49763	200067	99951	149842	99672	49832	50332	300541

4. Systems with normal distributed components

Now we will discuss the case of a system $\underline{X} = (X_1, X_2, X_3, ..., X_k)$ where its components X_j, $1 \le j \le k$, are random variables with normal distributions.

By $X \sim Norm(\mu, \sigma^2)$ with $\mu \in R$, $\sigma > 0$, we understand that the random variable X is normal distributed where $Mean(X) = \mu$ and $Var(X) = \sigma^2$. We denote by $\Phi(x)$ the Laplace function, that is the cumulative distribution function for the random variable $Z \sim Norm(0,1)$.

Remind some properties which will be applied in the subsequent.

P4.1. If $Z \sim Norm(0,1)$ and $X = \mu + \sigma Z$ with $\mu \in R$, $\sigma > 0$ then we have $X \sim Norm(\mu, \sigma^2)$.

P4.2 (Inverse method, [3], [4]). If the random variable U is uniformly distributed on the interval $[0,1]$ and $Z = \Phi^{-1}(U)$ then $Z \sim Norm(0,1)$.

P4.3. For any $\mu_i \in R$, $\sigma_i > 0$, if $X_i \sim Norm(\mu_i, \sigma_i^2)$ and $Y = X_1 + X_2$ then $Y \sim Norm(\mu_1 + \mu_2, \sigma_1^2 + \sigma_2^2)$.

Discretization procedure *DP*. For any $a \in R$, $\mu \in R$, $\sigma > 0$ and $X \sim Norm(\mu, \sigma^2)$ we designate by $B_{X,a}$ the following binary 0-1 random variable

$$B_{X,a} = \begin{cases} 0 & , \quad when \;\; X < a \\ 1 & , \quad when \;\; X \ge a \end{cases}$$

Using the procedure *DP* we deduce by a direct calculus

P4.4. For any $X \sim Norm(\mu, \sigma^2)$ we have $\Pr(B_{X.a} = 1) = 1 - \Phi((a - \mu)/\sigma)$

P4.5. For any $-1 \le c \le 1$, $Z_i \sim Norm(0,1)$, the standard normal random variables Z_1, Z_2 being independent, if

$$X = Z_1$$

$$Y = c Z_1 + \sqrt{1 - c^2}\, Z_2$$

then $X \sim Norm(0,1)$, $Y \sim Norm(0,1)$ and more $Cor(X,Y) = c$.

Remark 6. By using a normal random variable $X \sim Norm(\mu, \sigma^2)$ and a given bound $a \in R$ we build a binary 0-1 random variable $B_{X,a}$ such that

$$q = \Pr(B_{X.a} = 1) = 1 - \Phi((a - \mu)/\sigma)$$

(see the discretization procedure *DP* and *Proposition P4.4*). When $\mu = 0$ and $\sigma = 1$, the threshold $a \in R$ determine effectively the distribution of the discrete 0-1 random variable $B_{X,a}$.

5. A discretization process

Having a continuous normal distributed system $\underline{X} = (X_1, X_2, X_3, ..., X_k)$ and fixing some arbitrary thresholds $a_1, a_2, a_3, ..., a_k \in R$ we can obtain a binary 0-1 system $\underline{B} = (B_1, B_2, B_3, ..., B_k)$ with $B_j = B_{X_j, a_j}$, $1 \le j \le k$ (apply the procedure *DP*).

More, when $X_j \sim Norm(0,1)$, $1 \le j \le k$, then $q_j = \Pr(B_j = 1) = 1 - \Phi(a_j)$.

Obviously, in this last case, the correlation indicators $r_{ij} = Cor(B_i, B_j)$ and $c_{ij} = Cor(X_i, X_j)$, $1 \le i, j \le k$, have not equal values. More precisely, a correlation coefficient r_{ij} depends on the quantities c_{ij}, q_i, q_j. The effective relation between r_{ij} and c_{ij} indices will be established in the subsequent by applying a stochastic Monte Carlo simulation.

Remark 7. For an arbitrary $-1 \le c \le 1$, propositions *P4.2* and *P4.5* permit us to generate two dependent standard normal random variables X, Y having just the Pearson correlation coefficient $Cor(X,Y) = c$. We can apply *Proposition P4.2* (the inverse method, [3], [4]) to generate independent $Z_i \sim Norm(0,1)$ random variables which are used by *Proposition P4.5*.

Now, keeping all the previous notations, we will suggest a Monte Carlo procedure *MCRCC* to establish the real ratios between he correlation coefficients $c_{ij} = Cor(X_i, X_j)$ and $r_{ij} = Cor(B_i, B_j)$.

Procedure MCRCC.

Step 1. We generate random variates of volume n for a bidimensional random vector (X_1, X_2) with standard normal dependent marginals and $c_{12} = Cor(X_1, X_2)$, $-1 \le c_{12} \le 1$ (more details in *Remark 7*).

Step 2. Knowing the marginal probabilities $-1 \le q_1, q_2 \le 1$, we specify the discretization thresholds, that is $a_1 = \Phi^{-1}(1-q_1)$, $a_2 = \Phi^{-1}(1-q_2)$.

Step 3. We obtain 0-1 binary samples (b_1, b_2) from the random vector $\underline{B} = (B_i, B_j)$ considering the discretization procedure $B_1 = B_{X_1, a_1}$, $B_2 = B_{X_2, a_2}$ (algorithm *DP*).

Step 4. Using the samples resulted for $\underline{B} = (B_i, B_j)$ we estimate the correlation coefficient $r_{12} = Cor(B_1, B_2)$.

The correlation values r_{12} from *Tables 3-5* were deduced by running the Monte Carlo algorithm *MCRCC* for samples having the volume $n = 10^7$.

Table 3. $q_1 = q_2 = 0.5$, $n = 10^7$ ***Monte Carlo simulations with MCRCC***

c_{12}	-0.999	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4
r_{12}	-0.9714	-0.7129	-0.5906	-0.4938	-0.4099	-0.3335	-0.2621
c_{12}	-0.3	-0.2	-0.1	0	0.1	0.2	0.3
r_{12}	-0.1940	-0.1282	-0.0637	0.0001	0.0638	0.1284	0.1943
c_{12}	0.4	0.5	0.6	0.7	0.8	0.9	0.999
r_{12}	0.2622	0.3333	0.4096	0.4937	0.5904	0.7129	0.9714

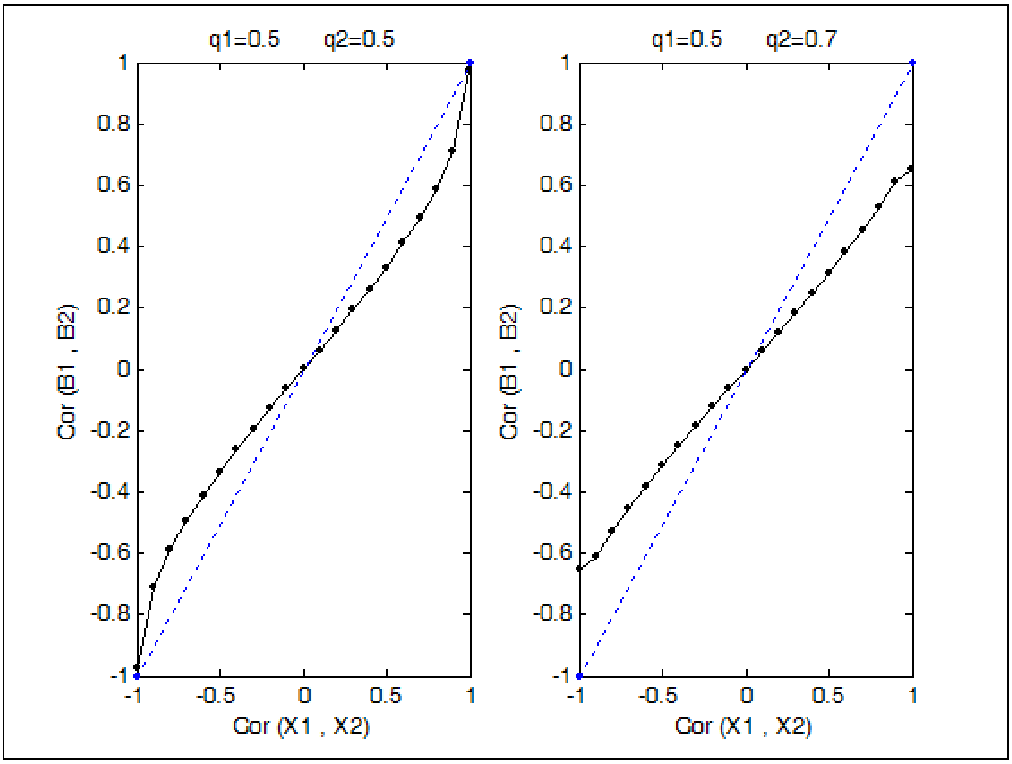
Table 4. $q_1 = 0.4$, $q_2 = 0.6$, $n = 10^7$ ***simulations with MCRCC***

c_{12}	-0.999	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4
r_{12}	-0.9713	-0.7106	-0.5872	-0.4902	-0.4060	-0.3298	-0.2588
c_{12}	-0.3	-0.2	-0.1	0	0.1	0.2	0.3
r_{12}	-0.1912	-0.1261	-0.0628	-0.0004	0.0616	0.1240	0.1869
c_{12}	0.4	0.5	0.6	0.7	0.8	0.9	0.999
r_{12}	0.2512	0.3173	0.3861	0.4589	0.5364	0.6181	0.6667

Table 5. $q_1 = 0.5, q_2 = 0.7$, $n = 10^7$ ***simulations with MCRCC***

c_{12}	-0.999	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4
r_{12}	-0.6546	-0.6091	-0.5293	-0.4529	-0.3809	-0.3125	-0.2472
c_{12}	-0.3	-0.2	-0.1	0	0.1	0.2	0.3
r_{12}	-0.1838	-0.1219	-0.0608	-0.0002	0.0605	0.1214	0.1834
c_{12}	0.4	0.5	0.6	0.7	0.8	0.9	0.999
r_{12}	0.2469	0.3124	0.3808	0.4530	0.5297	0.6091	0.6546

Remark 8. The differences between the correlation values $r_{12} = Cor(B_1, B_2)$ and $c_{12} = Cor(X_1, X_2)$ are sometimes considerable. *Graphic 2* gives us a suggestive illustration of this aspect (compare the differences between the continuous and dotted curves).



Graphic 2. The ratio between the correlation indices r_{12} and c_{12}

Remark 9. We can use successively *Proposition P4.5* and the discretization procedure *DP* to simulate directly samples from a tree type binary systems. See, for example, the one level tree system depicted in *Figure 1, case 1.3.*

6. Concluding remarks

We discussed two algorithms to generate random variates for a binary system $\underline{B} = (B_1, B_2, B_3, \ldots, B_k)$ with k components.

The algorithm *GDRV* uses as inputs all the probabilities $p_{i_1,i_2,i_3,\ldots,i_k}$, $i_j \in \{0,1\}$, $1 \le j \le k$, which characterize the binary system $\underline{B}$. It is not so easy to apply practically the procedure *GDRV* for systems $\underline{B}$ which have a lot of components. In this case the quantity $2^k - 1$ of the input data for *GDRV* algorithm becomes extremely large.

For this reason is suggested a new other algorithm based on the discretization procedure *DP* to obtain arbitrary observations from $\underline{B}$. This procedure simulate better the real aspects. The correlation structure of a continuous system $\underline{X}$ is inherited by the binary system $\underline{B}$ resulted after a discretization process. The relation between the correlation coefficients $c_{12} = Cor(X_1, X_2)$ and $r_{12} = Cor(B_1, B_2)$ can be determined by applying *MCRCC* algorithm (see also *Graphic 2*).

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Econometric Evidences of Political Business Cycles in Romania during the socialist regime and after

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Abstract

In this paper we analyse the link between politics and economics in Romania under the socialist regime and during the first years of democracy. To investigate this relationship, we focus on how the electoral moments (election's dates for Great National Assembly) or political events (years of Communist Party Congresses) are related to the change of economic performance between 1960 and 1989. For the situation after the Revolution in 1989, we analyse the regional evidences.

Keywords: Political Business Cycles, Vote Popularity Function, Partisan Behaviour, Regional Unemployment

1. Introduction

The political business cycle (PBC) can be seen as a business cycle that results (a) from the manipulation of policy tools (fiscal policy, monetary policy) by incumbent politicians in hope to stimulate the economy just prior to an election and thereby greatly improve their own and their party's re-election chances or (b) from the competition among political parties with different ideologies[1]. On that account, the theory of political business cycle investigates the relationship between political cycles and economic cycles, namely how the timing of elections, the ideological orientation of governments and the nature of competition among political parties influence unemployment, economic growth, inflation and the use of various monetary and fiscal policy instruments (Jula & Jula, 2008).

In this paper we analyses the link between economic conditions and political behavior in Romania under the socialist regime. In Romania, the democratic experience computes a small number of electoral moments. Therefore, it is not possible yet to build an electoral behaviour econometric model using the political time series. In these circumstances, in the following section, by the examination of the political and economic dynamics during the 1990-2008, we try only to identify some significant signals concerning the economic impact of the electoral timing. We use an econometric model to analysis the political behaviour using a regional economic and political data. The analysis is divided in two different approaches: the elections before 2008 and the elections from 2008 (when a new electoral law was introduced – mainly the impact of uninominal voting and the change in electoral preferences of the voters from local elections to parliamentary elections).

2. Data issues

The construction of political variables was based on information from the "World Political Leaders 1945-2005" database of Zárate's Political Collections (ZPC) [2] and the database of the Centre for the Study of Civil War World (Peace Research Institute Oslo), Norway [3].

The *Great National Assembly* (in Romanian: Marea Adunare Naţională) was the unicameral legislative entity of the Romanian People's Republic (1948-1965) and of the Socialist Republic Romania (1965-1989). As Parliamentary elections, The Great National Assembly was elected every four or five years. Election timetable is presented below.

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[1] Jula N.-M., 2010, Modelling of Political Business Cycles, Doctorate Thesis, Romanian Academy, National Institute of Economic Research, Bucharest
[2] http://www.terra.es/personal2/monolith/home.htm
[3] http://www.prio.no/CSCW/Datasets/Governance/

Table 1. Parliamentary Elections (for the Great National Assembly)

Year of election	*Largest party*	*Votes for the largest party % of total votes*	*Total votes*	*Total population*	*Voters as a percentage of the total population*
1946	People's Democratic Front	78.0	6 841 927	15 791 000	43.3
1948	People's Democratic Front	93.2	7 468 541	15 893 000	47.0
1952	People's Democratic Front	98.4	10 353 489	16 630 000	62.2
1957	People's Democratic Front	98.9	11 553 690	17 830 000	64.8
1961	People's Democratic Front	99.8	12 417 800	18 570 000	66.9
1965	People's Democratic Front	99.8	12 853 590	19 030 000	67.5
1969	United Socialist Front	99.7	13 577 143	20 010 000	67.8
1975	United Socialist Front	98.8	14 893 592	21 250 000	70.1
1980	Front of Democracy	98.5	15 629 054	22 201 000	70.4
1985	Front of Democracy	97.7	15 732 095	22 725 000	69.2

Source: Centre for the Study of Civil War, Peace Research Institute Oslo (PRIO), Norway.

As political cycle, we can mention that starting in 1955, there was one Communist Party Central Congress every five years, with an one-year ahead one in 1969.

Table 2. Party Congresses

Name	*Period*	*Location*	*Name*	*Period*	*Location*
First	May 1921	Bucharest	8th	June 1960	Bucharest
2nd	October 1922	Ploiesti	9th	July 1965	Bucharest
3rd	August 1924	Vienna	10th	August 1969	Bucharest
4th	July 1928	Kharkov	11th	November 1974	Bucharest
5th	December 1931	Moscow	12th	November 1979	Bucharest
6th	February 1948	Bucharest	13th	November 1984	Bucharest
7th	December 1955	Bucharest	14th	November 1989	Bucharest

Source: http://en.wikipedia.org/wiki/Romanian_Communist_Party

Data concerning the Romanian economy, from 1950 to 1989, are based on information from the *Penn World Table* (Heston A. et al. 2012). *The Penn World Table* provides purchasing power parity and national income accounts converted to international prices, for 189 countries/territories, for some or all of the years 1950-2010. The data for Romania cover the 1960-1989 period and are calculated both at current prices in national currency (leu) and at constant 2005 prices. The used variables in our analyses, based on information from the *Penn World Table*, are the following: Sum of household consumption expenditure and final consumption expenditure of NPISH's (NPISH: Non-profit institutions serving households); Sum of government collective consumption expenditure and government individual consumption expenditure; Collective consumption of government for public good type of activities; Domestic investment; Actual household consumption; Exports of goods and services; Imports of goods and services; Population (in thousand people); Exchange rate.

3. Election under socialism: The purpose of election and economic aftermaths

To understand how the electoral events influenced the economy of Romania in socialist period, we must first decipher the causes which led the communist authorities to organize elections under socialism.

The foremost reason may be that the autocracies with elections are more durable than those without them, so that the establishment of elections is a mean used by the dictators hold onto power. Geddes (1999) argues that average length of rule for a military regime is 8.5 years, for personal regime – 15 years, and for single-party regime – 22.7 years. But this should be a minor motivation for the communist party because, to paraphrase Kalecki (1943): "In a democracy, one does not know what the next government will be like. Under *communism* there is no next government". In communist ideology, once the power is gained, the communist system lasts forever!

By surveying the literature, we try to identify what is the purpose of elections in the dictatorships regimes.

(1) Schneider & Frey (1988) says that: "No government, not even the most dictatorial, is completely independent of the support by the population".

(2) Schedler (2006, p.13) argues that elections help autocrats establish legitimacy at home or abroad.

(3) Geddes (2005), Malesky & Schuler (2008) and others consider that the authoritarian regimes use the overwhelming electoral victories as a signal to members of the regime elite that opposition is futile.

(4) Gandhi & Lust-Okar (2009) view authoritarian elections as an institutional tool that dictators can use to co-opt elites, party members, or larger groups within society [4].

(5) Li (2011) argued that elections provide to single-party authoritarian regimes information about the loyalty and competence of their own party

Based on these findings, we tried to identify in Romania, during the socialism, signs of politico-economic cycles and to explain the reasons of such behaviour. We investigated how the change in macroeconomic variables is related to the political events (congresses of the Communist Party), and the electoral moments (elections for the Great National Assembly), between 1948 and 1989. Except 1965 and 1969, electoral moments do not overlap the political ones.

Dynamics of investments rates, computed as the ratio of investment to gross domestic product (at current prices) is shown in the graph below. In the same graph, we represented also the trend calculated by the Hodrick-Prescott filter, and cyclic variation as the difference between series and trend.

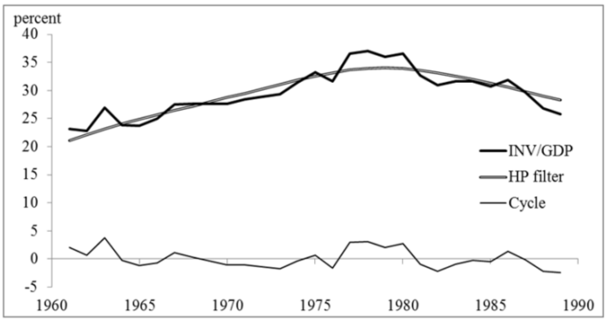

Fig. 1. Dynamics of investment rates

Source: Authors' calculations based on *Penn World Table* (Heston A. et al. 2012)

We calculated the average values of investment rates near the political events (congresses of the Communist Party), and around election time (elections for the Great National Assembly).

In the years when the Romanian Communist Party congresses were held, there was a slowdown in investment programs. The capital investment plans are revised downwards in order to make it possible to grant the population a more rapid rise in real wages (Schneider & Frey, 1988), and to decrease the inhabitants' dissatisfaction related to the level and quality of public services (other than those linked to the repression – police, army, informer). The average of consumption rate as % of GDP, around the times of political events is shown in the graph below.

[4] Gandhi J., Lust-Okar E. 2009, Elections Under Authoritarianism, Annual Review of Political Science, vol. 12: 403-22

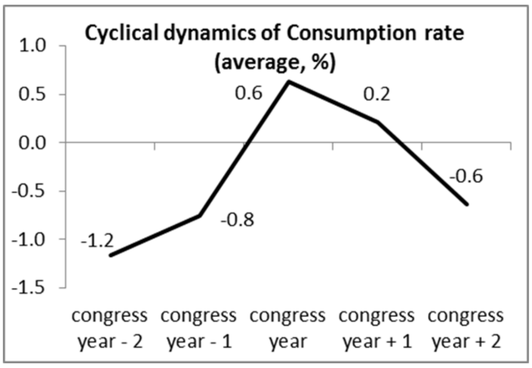

Fig. 2. Political consumption cycles

(Consumption rate is computed in per cent, as sum of household consumption expenditure and final consumption expenditure of non-profit institutions serving households, divided by gross domestic product, at current prices).

If we look at parliamentary election (election for the Great National Assembly), there is no signal of *political investment cycle*.

On the contrary, there is a counterintuitive investment growth rate in election years. This is counterintuitive because standard theories of politics begin with two simplifying assumptions: (a) Politicians want to achieve office and remain there; (b) the best strategy for surviving in office is to give constituents what they want (Geddes 1999). And it is unlikely that Romanian voters wished to increase steel production per capita, instead of consumer goods[5].

4. The politico-economic models

The link between politics and economics in Romania in the socialist regime is analysed through the econometric models. To investigate this relationship, we focus on how the electoral moment (time of election for Great National Assembly) or political events (Communist Party Congresses years) are related to the change of economic performance under the socialist regime (1948-1989).

We have built econometric models of the relationship between politics and economics as follows:

$$y_t = a_0 + \sum_i a_i x_{it} + \alpha \cdot POL_t + \beta \cdot ELECT_t + e_t, \qquad (1)$$

where:

y – is an economic variable (gross domestic product, consumption, investment etc.);

x_i – are the control variables;

POL – is a political dummy variable, that take value POL = 1 in the years when the Romanian Communist Party Congress was taken and POL = 0 otherwise;

ELECT– is an electoral timing dummy variable, that take value ELECT = 1 in the electoral years (election for Great National Assembly) and otherwise ELECT = 0.

The equations are presented with details in in the paper *Political Business Cycles in Romania, during the socialist regime*, D. Jula, N.M. Jula.

The link between political events and economic is measured by α coefficient. If α is significant, then a political behaviour near congress influenced the economic variable, in the meaning given by the sign of alpha.

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The link between election and economic is measured by β coefficient. If β is significant, then a political behaviour near election influenced the economic variable, in the meaning given by the sign of β.

For all the equations, we reject the heteroskedasticity (through used both the Breusch-Pagan-Godfrey Test, as well as White – no cross-term heteroskedasticity test), they aren't autocorrelated (Durbin-Watson and Breusch-Godfrey serial correlation LM test, for lags = 4) and the distribution of the disturbances is normal (Jarque-Bera normality test).

For *investment regression equation*, in addition to Durbin-Watson statistics (inconclusive when among the explanatory variables are lagged endogenous variables) we compute Breusch-Godfrey Serial Correlation LM Test, for lags = 4. On additional equation, $nR^2 = 6.126 < \chi^2(4) = 9.488$, which means that errors are not correlated, at least up to rank 4. This hypothesis is also supported by applying the BDS (Brock, Dechert & Scheinkman) Independence test on residual variable: the residuals are independently distributed (with epsilon = 1.5 standard deviations, maximum correlation dimension = 6, and 10000 bootstrap repetitions). We performed a similar analysis for GDP equation.

The equations for *investment* and *consumption* confirm the previous analysis. Years with political events (Communist Party Congresses years) tend to have lower investment and higher consumer expenditure. In other words, economic policy instruments are used around elections to minimize the risk of riots, due to dissatisfaction associated with economic and social situation.

These results are detailed in the paper Political Business Cycles in Romania, during the socialist regime, D. Jula, N.M. Jula and in Residual Effects in Regional Vote and Popularity Function, Jula D., Jula N.[6]

5. Parliamentary elections from 2008

We have analysed here the electoral behaviour from a different approach. We have studied the impact inducted by the state and dynamics of some economic variables on the change of voting intensions from the local elections from June 2008 to parliamentary elections, same year.

The results from the electoral elections from June 2008 are econometrically significant [7]. The vote was mainly driven by local leaders and important regional personalities.

The data are analysed in regional structures. We used a Paldam type model. In its most simple linear version the function are:

$$\Delta P_t = \{a_1\Delta u_t + a_2\Delta p_t + \ldots.\} + [c_1 D^1{}_t + c_2 D^t{}_2 + \ldots] + e_t \qquad (2)$$

Concretely, we have analysed a model like:

$$P_{ij} = \{a_0 + a_1 \cdot cj_{ij} + a_2 \cdot prescj_{ij}\} + [a_{3,i}(rs_{nov2008} - rs_{mai2008})_j] + e_{ij}, \qquad (3)$$

where:

P_{ij} - represents the share of votes won by the competitor *I* in county *j*, to the total number of valid votes in that county, in the Parliamentary Elections from November 2008;

cj_{ij} - represents the share of votes won by the competitor I in county j, to the total number of valid votes in that county, in the elections for the Local Councils, June 2008;

$prescj_{ij}$ - dummy variable, prescjij = 1, when party I won the Presidency of Local County j, Local Elections 2008 and prescjij = 0, otherwise;

rs_j - unemployment rate in county j; nov2008 = 30 November 2008, mai2008 = 31 May 2008;

[6] Jula D., Jula N.-M., 2008, Residual Effects in Regional Vote and Popularity Function, Jula D., Jula N., 2008, "Residual Effects in Regional Vote and Popularity Function", 48th European Regional Science Association Congress: Culture, Cohesion and Competitiveness: Regional Perspectives, Liverpool, UK, http://www.liv.ac.uk/ersa2008/conf/rsa98.pl?conf=ersa2008&type=showabstr &nr=263

[7] idem

a … - parameters of the model;

eij - error of regression equation, random variable.

The used data are in regional structures and refer to the first 3 parliamentary parties (PSD+PC, PD-L and PNL). The obtained results are:

Table 3. Election results using regional structures

	Chamber of Deputies		
	PSD	PD-L	PNL
Constant	6.8377 (6.94)		
CJ?	0.6400 (16.684)		
PRESCJ?	5.3823 (4.539)		
$RS_{nov2008}$-$RS_{mai2008}$	2.1514 (1.944)	2.4978 (2.085)	-3.0629 (-2.517)
R^2	0.8397		
R^2 adjusted	0.8330		

	Senate		
	PSD	PD-L	PNL
Constant	6.5888 (6.684)		
CJ?	0.6735 (17.553)		
PRESCJ?	6.1834 (5.155)		
$RS_{nov2008}$-$RS_{mai2008}$	1.8465 (1.679)	2.5053 (2.009)	-3.6142 (-2.856)
R^2	0.8548		
R^2 adjusted	0.8487		

(in brackets, under the estimators, there are standard deviation values; the estimators have a confidence level over 90%)

The results suggest an interpretation consistent with the theory of economic voting: in the period June to November 2008, Liberal Party was the party of government. Increase of unemployment in regional structures resulted in a penalty for PNL and an increase in intentions to vote for opposition parties (PSD and PDL). Estimators are econometrically significant.

For an extended analysis, we recommend the paper *Econometric Analysis On Vote-Popularity Function For Romania*, Jula, Nicolae-Marius; Jula, Nicoleta, CKS - Challenges of the Knowledge Soc; Jan 2011, p1101, Conference Proceeding.

5. Conclusions

Economic policy instruments are used around elections to minimize the risk of riots, due to dissatisfaction associated with economic and social situation. The party members impulse the economic growth to signal their loyalty and competence, pursuing the promotion to the central leadership or to the local line-ups of communist party, promotion associated with more privileges and a better future career chance. In consequence, we found evidence of political-economic cycles if we used the dates of the communist party congresses as political variable. Around the years with communist party congresses, there was a slowdown in investment programs, in order to have the possibility to offer the population a more rapid rise in real wages and consumption and to decrease the inhabitants' dissatisfaction related to the level and quality of public services (other than those linked to the repression mechanisms – police, army, informer).

Regarding the economic voting for the Parliamentary elections from November 2008, the increase of unemployment in regional structures resulted in a penalty for PNL (as the party in office) and an increase in intentions to vote for opposition parties (PSD and PDL).

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