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**Title of Paper**

An architecture based on SOA, RESTful and Mashup for C2 mobile applications

**Topic**

Architectures, Technologies and tools

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## **Abstract**

The development of service-oriented architectures for C2 systems in mobile applications has major challenges for security and availability of services. The construction of secure services causes an increase in the bandwidth required for the service to be provided and impacts the way those services are made. This study aims to present an alternative for mobile agents be able to consume RESTful services using thin clients and providing increased situational awareness by dynamic interactions with the databases handled by Web services using Mashups. This construction allows us to consult, write, or to dynamically modify individuals persisted in triple stores, even with limitations in bandwidth, providing security in the same HTTPS structure that still permeates government's Intranets.

## **1. Introduction**

It is not hard to find information technology (IT) structures where technicians tried to follow the technological development over time. In such situation is common to find multiple systems that manage portions of specific activities of an organization. Current solutions work for systems that make access to different databases through networks that have been segregated to support the core activities. The big challenge is to provide resources that would not be available via the Internet in a scenario where there is a need to share different information in a coordinated manner and in an environment of Network Centric Warfare (NCW).

An attempt toward increasing interoperability between systems was the adoption of open standards, but this does not solve all the problems of IT Governance. There are two complicating aspects of technology standardization: numerous artifacts acquired and developed with technologies already incorporated and many physically dispersed organizations with different missions and technology needs. Even if it were possible to have the technologies being standardized, new languages and paradigms of software development, and with more features, increase the difficulty of systems interoperability, mainly by legacies that will live in this new structure.

A commonly adopted solution is the utilization of service oriented architectures (SOA). The premise is to create an Intranet service with high speed and throughput that allows access to data quickly and reliably. That is, we have no more complex applications, but services will be incorporated into the network in question. The proposed architecture for a SOA-based system aims to avoid each organization

having a specific need, not direct resources to a single solution to your problem, but create a service that can be shared by other organizations and is reusable in future systems.

Bringing this vision to a context of military applications, the need of a command as a service will be added to other existing services in the portfolio of the military command, making it available for use in C2 systems. The business requirements are not met through the development of applications, but the simple composition of existing services in new settings. When the compositions become more common, the concept of application begins to disappear [3]. The application now is a service composition and new needs can be resolved through the change in the service's inventory, now available.

The purpose of the present work is to show that the development of model-based Mashups with the API availability over an Intranet, allows the reuse of services, which would facilitate the development of future projects. For this approach we use the REST architecture, the most advantageous in scenarios where there are great distances between the organizations and there are many channels of data, with too many variations in the available bandwidth for the services' access.

Figure 1 below shows the solution based on isolated applications without the service concept. The effort to interoperability is great and the cost is high, more feasible to develop a new version of the application that includes all the features. The databases are distinct and designs are also managed by different teams and with little or no interaction. Security permissions are based on individual solutions.

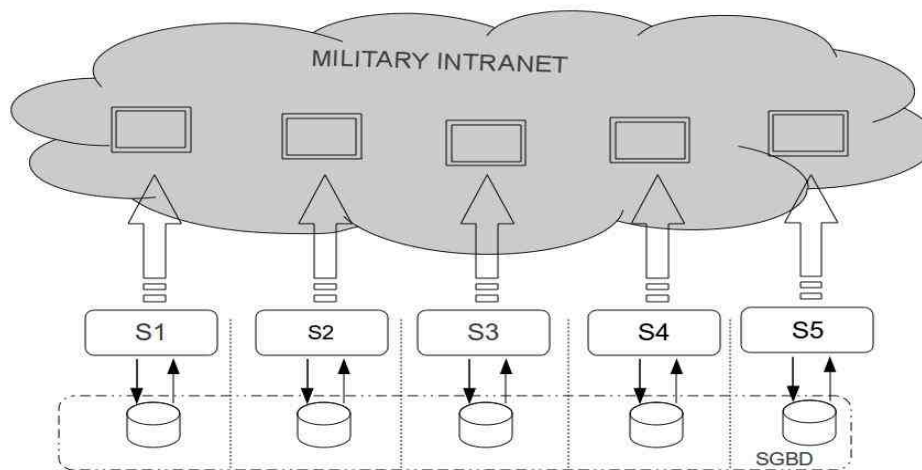


Figure 1 - Five isolated applications published in a military Intranet.

Figure 2 shows a scenario with service composition. The system services S1 to S4 are published on the portfolio; gray circles represent the services implemented; the open circles represent the composition of services required for the operation of the system S5. The system S5, then uses a shared service with the S4 system. This service will be incorporated into the portfolio that could be used by other organizations.

In the case of C2 systems, the entire portfolio service is available without the need to develop specific systems for handling data already dealt with by existing systems, and if any additional requirement exists we can add a service to the portfolio (shaded circle) that could be possibly used by other organizations.

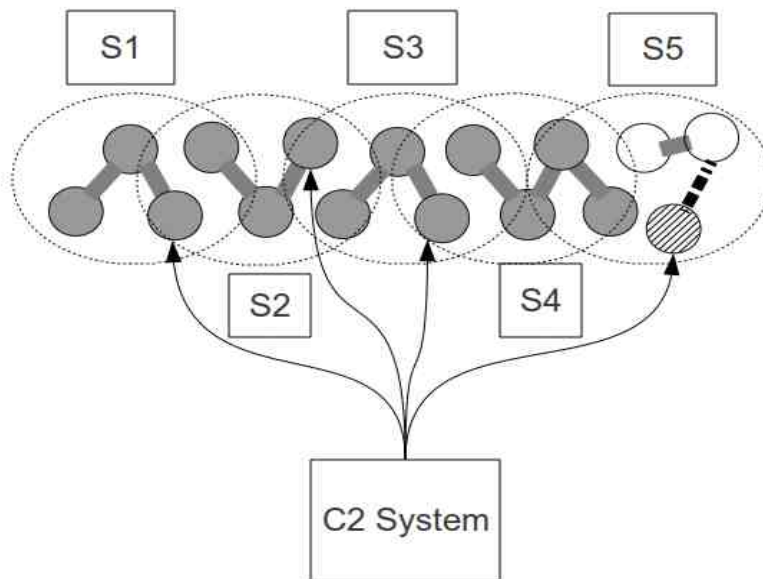


Figure 2 - A C2 system based on the portfolio services.

## 2. Basic Concepts

### 2.1 Mobile Agents in NCW

When aggregating operational commands and actuators (weapon systems) into the net, a universal battle space image could be generated, keeping the node in condition to influence the combat through the flexibility in receiving ad-hoc requests and transmitting the joint coordination orders [1].

The cyberwarfare network-centric (NCW). In this context, joint operations are related to strategic military actions, managed via software that process data using connection-based data networks. The data in these transactions flows through different channels and through various encodings: VHF, UHF, bits, Datalink, satellite link, Ethernet Bus, etc..

In NCW, interoperability is the key aspect to be developed and is the ability to transfer and use information consistently and efficiently across multiple organizations and information systems [1].

In this context, a mobile unit is any object, point or extension that changes the value of its space attribute over time. These are devices that move continuously, changing its position in space with the passage of time [1].

With advances in mobile technology, most of these devices are capable of storing a wide variety of data. The paradigm of mobile computing has affected concepts, models and assumptions in many traditional areas of computer science. In the network area, it is necessary that the devices are connected to the network regardless of location, which is known as ubiquitous computing [15]. The mobile computing comes down to several components, possibly heterogeneous, connected to a wireless network that is connected to a network with fixed antennas.

## **2.2 SOA and Web Services**

Web 2.0 applications typically offer a service that describes the content generated for users, so other applications have the ability to access and reuse this content for other purposes, usually different from the original intentions of the application provider [17]. The services are physically independent software programs with different design features that support the strategic objectives of the paradigm of service oriented architecture. Each department functions as an API having its own contract. The goal of SOA is to establish a native interoperability within the portfolios [3]. Although conceptually appear before SOA, Web Services are a set of protocols through which services can be published, discovered and used in a neutral and standardized way. Web Services provide certain architectural characteristics and benefits, specifically platform independence, loose coupling, self-description, and discovery and can enable the formal separation between the provider and consumer because of the formality of the interface [11]. When we refer to Web Services in SOA we have a direct view of the SOAP protocol and

XML-RPC, but the REST architecture is much more efficient solution for thin clients because it uses the HTTP infrastructure [3].

There are several development tools and when used over HTTP, it is hardly blocked by firewalls and proxies. RESTful is an architecture completely based on the proposed REST, not requiring little or a great infrastructure and middleware for WS-\* or additional intermediate layer. It uses the web itself as a means of transport, so it demands a low bandwidth for the network and is used by most Web 2.0 applications [10-13]. However, it is not suitable to travel large volumes of parameters via Uniform Resource Identifier (URI), where PUT / POST for inclusion of data, for example.

### **2.3 Ontologies**

Ontologies can act on data sources providing more effective organization and retrieval. Enable a common understanding and a shared domain. Play an important role in information exchange, to provide semantic structure to the data sources [4]. Defines a field, or more formally specifies a conceptualization about a domain of interest. It is organized in a hierarchy of concepts, allowing the description of rules and relationships between concepts.

The semantic expressiveness of existing content in Web 2.0 applications and interoperable communications provided by Web services can be considered the main catalysts in the exponential growth of the Web. Through OWL-S is a semantic extension of OWL(Ontology Web Language for Services) is possible by mapping of Grounding OWL-S/WADL held by the ontology RESTfulGrounding, inspired by this OWL-S/WSDL Grounding in OWL-S specification itself, create semantic services with RESTful Web Services [17].

### **2.4 Mashups**

Mashup is a personalized portal or a web application that uses content from more than one source to create a new full service. The creation of a service is made through two or more API from existing data. Some examples are Yahoo Pipes, Google Maps and Twitter. They are light loosely coupled services, which facilitates their access via mobile devices [2-10]. Basically Mashups is a mix of various data sources, using RESTful. Web Services are lighter and can provide services with low bandwidth in order to connect mobile customers. The mobile nodes can easily deal with HTML and JavaScript technologies through a simple browser. A Mashup is the result of rapid development in small scale.

## **2.5 Security**

Military communication systems have strict security policies, Which in some cases require ensuring that no piece of information, however small, is allowed to flow from one information domain to another [14], acting as a diode. A diode is placed between networks or domains, and ensures that information can only flow one way between these networks, like a civil network to a military network domain. It acts like a data pump capable of moving data from a domain of low classification to a domain of high classification. Along the same lines, even Web Services which do not have a return parameter usually need some acknowledgement on the HTTP layer for the completed transaction. The diode has piece of software on both sides of the gateway that can function as a wrapper service and a wrapper client, respectively. We have implemented a service wrapper in the lower domain using WSDL from the Web service we want to submit data to the higher domain. The standard REST service description is the WADL (Web Application Description Language), already adopted by Yahoo[14].

## **3. Our contribution**

As part of the proposal of this work we are making use of ontologies for service composition and making them available via the Intranet. Figure 3 shows that the data would be persistent in the original basis: trough the publication layer and service availability, with a single login, the client, using a mobile device, would have access to services provided by all agencies in the Intranet. The question becomes how to structure an architecture aimed at expanding the available services using existing databases and a single authentication for the access to the resources [8].

The proposed solution is based on Mashups publishing their API's, which would facilitate the future development and cost reduction. Security must be treated by a specialized team analyzing all the used protocols. The use of VPN and diode increase safety for publishing services, previously available on the military Intranet, via the Internet in joint operations, without the need to use a special and dedicated network. Access to the organizations databases by C2 systems would be transparent to the generated applications.

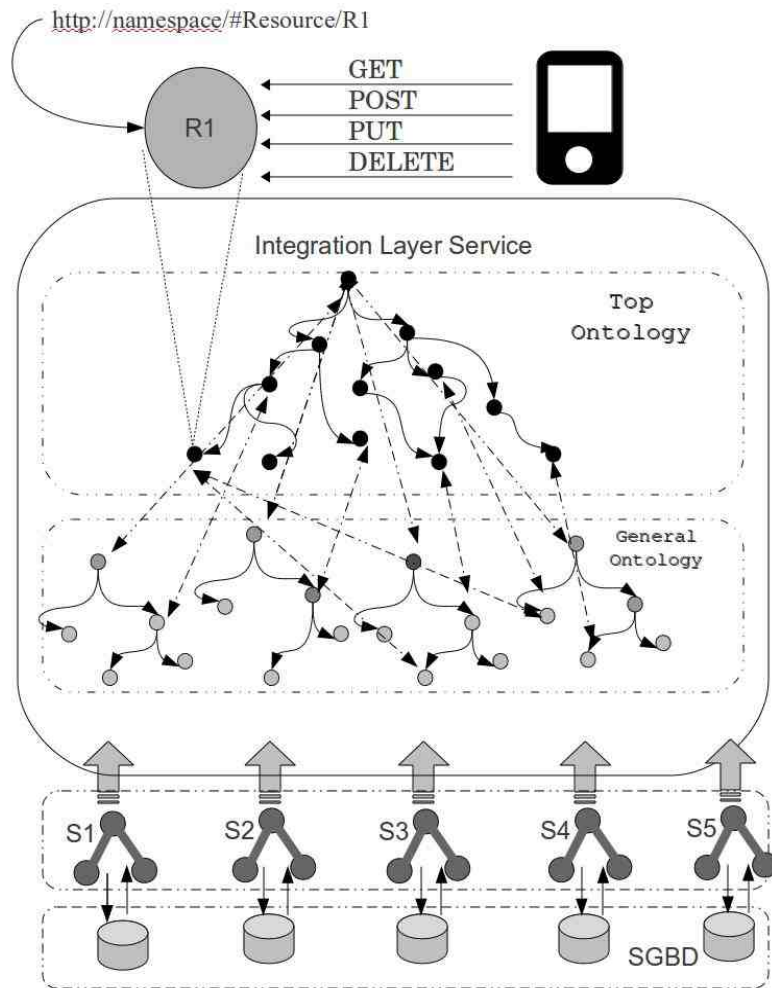


Figure 3 – The proposed architecture schema for C2 systems.

Our proposal presents simple models, practical and aligned with the implementation models of Web 2.0, but there are some limitations of the model REST: The communication must be point-to-point, not usable for distributed computing environment; lack of support for standards and security services that have more complex requirements. A final limitation would be the dependence on HTTP transport model.



## 4. Proof-of-Concept Implementation

The used technologies were the Eclipse IDE for Java EE Web Developers, Joomla (Dynamic portal engine and content management system), Restlet (Framework with support for REST architecture), Google API and features from an organizational Intranet. Three experiments were performed as proof of concept.

The first was the change in dynamics of an .OWL file via a RESTful client. The ontology develop on the software protégé was simulated in framework Restlet by changing its basic classes in java. Then possible to simulate a service published in RESTFUL with semantics. Hosting an .OWL file containing the academic publications database of ITA (Aeronautics Technological Institute) on a server was possible to pose a query through an URL and then change or enter a new data into the ontology. In another query was possible to confirm the data manipulation.

The second experiment, shown in Figure 4, was to build an ontology in through Protégé IDE with at least three classes simulating services used by a military organization within the Intranet. It was found that through the triple it is possible to achieve any service by scrolling through the three hierarchies of different ontologies used in the administrative areas of human resources, financial and military concept.[9].

The third experiment was to consume an available service Mashup, Google Maps, using its API for viewing data stored on the military Intranet via the Internet URI. The second version of software control documents in Brazilian Air Force have a high cost of development and main feature applied for monitoring the distributed documents, ie when it is sent to another organization. A simple solution would be using Mashups one last document output encoding, the first three digits would be linked to other organization and the serial numbers of the same type of documents. The target organization would publish in its API and it would be possible to see through the Intranet military.

This access was also possible via VPN using an asymmetric key by Internet connection. Through the API it is possible to visualize data from the three simulated classes.

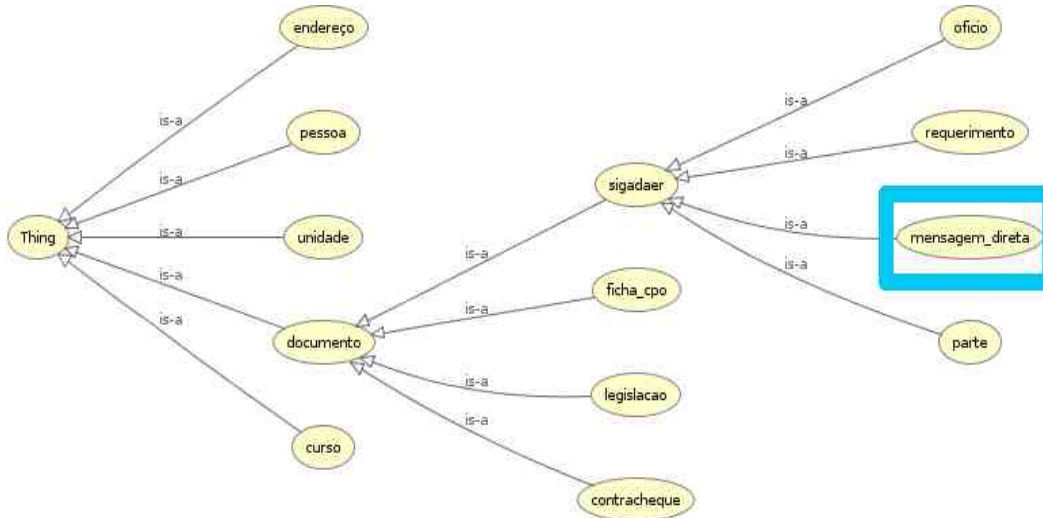


Figure 4 – Three ontologies integrated in a single area simulating all military administrative controls. In blue addressable resources by RESTful services: [http://localhost/documento/sigadaer/mensagem\\_direta](http://localhost/documento/sigadaer/mensagem_direta).

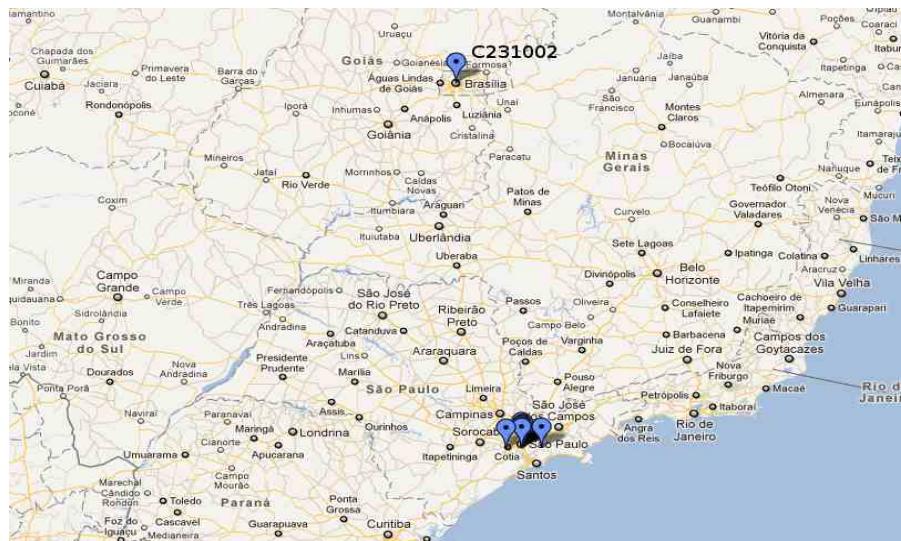


Figure 5 – View a document C231002 sent to a military organization the state of São Paulo to the capital Brasília.

For the application layer was used the Joomla content management system. Resources were manipulated and stored in the local cache, reducing the access time

for new consultations [6]. The access was made through a mobile device with 3G wireless.

## **5. Related Work**

There are several papers on interoperability of data systems. To implement a service that can access databases active in a joint operation, allowing access via mobile device is a complex and challenging task [7]. By exposing corporate information systems, it is important that security is adequate and directional flow of data is controlled. Work on Mashups show that you can log only having access to proprietary platform technologies supported by the service. Mashups represent an interesting challenge in the area of IT Governance by the ease of development with reuse and lack of maturity in the construction of complex systems.

## **6. Conclusions**

The paper proposes a flexible approach where systems are services compositions published in the portfolio. With the API reuse is possible to add resources to another organization, reducing costs and standardizing the development. To fully exploit the potential of network-centric C2 compositions, with services publications via Web Services, an architecture using SOA, RESTful and Mashups was developed, showing that one secure access was made through low bandwidth networks.

The major contribution of this research is to show that using mobile devices with 3G connections it is possible to access databases through authentication and keeping security to update C2 systems and controlling the nodes in a NCW scenario and even with limited bandwidth such a device can navigate through the various URI contained in ontologies and infer knowledge using OWL-S.

The very simple experiments served as the basis for a pilot project that can be far more complex, aiming to facilitate a personalized and lightweight access without location restriction.

## References

- [1] José C. S., “*O modelo de dados da OTAN para intercâmbio de informações de comando e controle: conceituação, aplicações e reflexos para o SC2FTer / SISMC2*”, TCC, ECEME, 2006.
- [2] Paul de Vrieze, Lai Xu, Athman Bouguettayay, Jian Yangz and Jinjun Chenx, “*Process-oriented Enterprise Mashups*”, Workshops at the Grid and Pervasive Computing Conference, 2009.
- [3] Thomas Erl “*SOA princípio de design de serviços*”, Pearson , São paulo, 2009 ISBN – 978-85-7605-189-3
- [4] Antoniou G. and Harmelen F. V., “*A Semantic Web Primer*”, Second Edition, MIT Press, 2008.
- [5] Couloutis Dollimore J. and Kindberg T, “*Distributed Systems, Concepts and Design*”, Addison wesley, 2010.
- [6] Caratti R. e Mafra L. S., ”*Joomla Avançado*”, Novatec, São Paulo, 2010 .
- [7] Breno O. B.; Guerra E. M. e Salles A. P., ”*Arquitetura Orientada a Serviços para o Suporte a Interoperabilidade de Aplicações de C2*”, XII SIGE, ISSN: 1983 7402, São José dos Campos, São Paulo, BR, 2010 .
- [8] Jon Lathem, Karthik Gomadam and Amit P. Sheth SA-REST and (S)mashups : “*Adding Semantics to RESTful Services*”, International Conference on Semantic Computing IEEE 0-7695-2997-6/07, 2007 .
- [9] Yong-Ju Lee and Chang-Su Kim, “*A Learning Ontology Method for RESTful Semantic Web Services*”, IEEE International Conference on Web Services , 2011.
- [10] Jon Lathem, Karthik Gomadam and Amit P. Sheth,” *SA-REST and (S)mashups : Adding Semantics to RESTful Services*”, International

Conference on Semantic Computing IEEE 0-7695-2997-6/07, 2007 .

- [11] Yong-Ju Lee and Chang-Su Kim, “ *A Learning Ontology Method for RESTful Semantic Web Services* ”, IEEE International Conference on Web Services , 2011.
- [12] Yong-Ju Lee and Chang-Su Kim, “*Building Semantic Ontologies for RESTful Web Services*”, International Conference on Computer Information Systems and Industrial Management Applications (CISIM) , 2010.
- [13] Allamaraju S., ”*RESTful Web Services Cookbook*”, O’REILLY US, 2010 .
- [14] Trude Hafsøe and Frank T. Johnsen ,”*Employing Web services between domains with restricted information flows* ”, 16th ICCRTS , Collective C2 in Multinational Civil-Military Operations, 2011.
- [15] Shao-Jie Mao, Yu-Ping Li, Jian-Ning Lin, Ke-Bo Deng, Li-Yang Sun,” Network Centric Simulation Architecture”, 15th ICCRTS, “The Evolution of C2”, 2010.
- [16] Hiroshi Maruyama , Taiga Nakamura , Tony Hsieh ,”Optimistic Fair Contract Signing for Web Services ”, ACM Workshop on XML Security, October 31, 2003, Fairfax VA, USA.
- [17] Otávio F. F. Filho, Maria A. G. V. Ferreira, “Semantic Web services: A RESTful Approach ”, IADIS International Conference , 2009.