LVC SIMULATION AND AUGMENTED REALITY TECHNIQUES WITHIN A VIRTUAL OPERATION CENTER FRAMEWORK

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ABSTRACT
Social networks, crowd sourcing, powerful mobile devices and the latest M&S technologies associated with Virtual Worlds and Augmented Reality are key areas of innovation in designing a next generation of Simulation and Command and Control (C2) framework for the military M&S Domains.

This framework looks at the latest role of LVC simulation that is evolving and increasing its fidelity level. Furthermore it implements new consumer technology trends and ways to maximize the efficiency of Simulation in military training and C2 Stimulation.

The first issue to be solved thinking about a next generation framework to develop an effective and efficient stimulation between LVC Simulators and C2 Systems is interoperability. Secondly, there is the opportunity to benefit from the lessons of social media so as to advance both the organizational model (particularly around team processes) and gain quicker access to the knowledge and intelligence gathering capabilities of experts and the wider civilian population ("crowdsourcing").

The authors' research outlines a new model regarding for the information flow between a Joint or Land Command Post and warfighters. This research takes into consideration the proposed model of a next generation C2 organization.

Keywords: LVC Simulation, Augmented Reality, Command and Control, Interoperability, Crowdsourcing

1. INTRODUCTION

This paper presents the Author's research into the latest trends and roles of Live Virtual and Constructive (LVC) Simulation and related implementation using the state of art Augmented Reality and Virtual World technology. In particular for the military environment the authors are studying how different but connected technologies can lead military training and digital C2 Environment.

At the core of our research activities in LVC simulation, Augmented Reality and C2 stimulation is an assumption that a new framework can provide an "*augmented capability to decide*" for Commanders, staff, specialists and warfighters to better understand the operational environment that surround them.

To understand possible innovation and trends about the interaction between C2 systems and LVC simulators, or better how C2 systems and simulators can stimulate each other, the authors focus on the CFR (Command Feedback and Response) concept. This concept introduces a new way to think about the Command and Control military organizational model. It is represented by the authors as a next generation of a C2 organizational model that takes the advantage of an immersive and interactive crowd-sourced and networked environment. What has been defined as the "Virtual Operation Center (VOC)", represents the traditional Command Post served with Digital devices and technologies and stimulated by live data, analysis, LVC Simulation and may be accessible via augmented reality techniques.

The trend in the training environment to use augmented reality and LVC Simulation points towards a future where commanders request a full C2 LVC immersive and interactive environment to support both operational planning and operations within embedded training capabilities.

Looking around us the social networks, mobile devices technology and M&S associated to virtual worlds and augmented reality are influencing the design of the next generation of communication in the global world.

Analyzing the global communications market the authors note the rapid rise of a wide spread phenomenon of social networks, amplified by the increasingly intensive use of mobile technology like smart phones and tablets. These devices are featured with full computational and networked communication capabilities, with a growing number of applications having access to complex mapping data, 3D visualization and augmented reality display via smart devices. One issue of note is that most of these services require ubiquitous high bandwidth Internet access. These trends support the increasing use of Simulation and C2 systems in the military LVC M&S domains, and are shaping the minds of new warfighters and will shape the next generation of C2 organizational models in a network centric or network enabled capabilities paradigm.

2. VIRTUAL OPERATION CENTER FRAMEWORK (VOCF)

What the authors named VOCF looks at these trends figuring out how they are impacting on the development of tools and applications, in a SOA (Service Oriented Architecture), to provide a "*full duplex*" stimulation between next generation of C2 systems and LVC-IA simulators. This concept verges on an immersive

interactive environment to support military training, operational planning and operations.

The research takes into consideration, in a comprehensive approach, six aspects:

- An evolved C2 organizational model, shaped by crowdsourcing and cross functional teams emerging concepts;
- Standard interoperable languages, that have to guarantee a common understandable way of communication layer between applications, systems and human being;
- Information assurance approach to allow and to optimize information sharing flows and policies;
- LVC and IA-CGF interaction in federated architecture such as DIS, HLA and TENA;
- Augmented reality techniques like an enabler transversal technology to stimulate as much as possible, the human visual sense in an immersive and interactive virtual-real experience that the authors named the "VIREAL";
- Operational scenario and architecture.

1.1. Evolved C2 Organizational model

The VOCF concept has been developed through an evolutionary approach applied to the traditional C2 organization based on the staff-line management model (that remains however the pillar of a military type organizational structure), to a flatter one inspired on a first side by the crowdsourcing social networking model, based on the ideas of distributed problem solving and production model, dispersing leadership and self-synchronization. As a second perspective the military cross functional team approach, according to the latest NATO trend about C2 organization, could be identified as a transversal staff management model. This kind of management, reorganized in what the authors named "virtual teams", can be thought as new model of mission oriented skills and expertise driven by crowdsourcing capabilities to join these teams. This organizational model aims to pull together the people with the right skills, interests and experience to fulfill a complex task transversally to the functional area approach. Remote collaboration technology featuring social Enterprise functions such as expert discover can now support an end-to-end virtual team creation d workflow process including "recruiting" from a "crowd" of authorized mission experts. This virtual team can be formed, trained and collaborate in a virtual space enhancing the speed of team formation, the team's availability to each other, and the collaboration capabilities. This new approach shifts the challenge of team creation from selecting who is immediately available locally towards gathering the appropriate mission oriented skilled and expert resources without immediate regard for their current physical location. This type of social Enterprise also offers great opportunity for each person to gain reward and recognition of personal skills by participation within the system so that effective personnel automatically begin to stand out within the "crowd". This opportunity to "gamify" (from the term "gamification") social recognition rewards has the benefit of being something that younger staff are already familiar with through gaming and social media and adds the opportunity create a strategy about what behaviors should be emphasized within the teams and what aspects of the culture need to be minimized by avoiding anything that rewards those negative behaviors.

In this model Information Assurance has a primary floor to keep the data and information secure but sharable. The right approach is to be searched in a balance between the intelligence paradox (don't know, don't do vs. know and do) and military crowd security and accreditation policies (pre-assessed and registered crowd "self"-assigned to tasks).

1.2. Crowdsourced Virtual Operation Center

The virtual C2 model defined by the VOCF concept can be envisioned and implemented with a crowdsourced "multidimensional" environment, and it is visually represented through immersive technology. This networked environment makes it possible to increase affordances and leverage global talent with knowledge, expertise, interest and access rights to join virtual cross functional teams in a boundless command post. Managing properly this environment it is possible to connect and to collaborate between people who have the right "need to know" and knowledge, but who are physically distributed in different locations.

In military applications what the authors want to focus on is about the action specific perception – intelligence tempo – to enable commanders and staff's capability to perceive, the real situation from graphical and visual representation of pieces of information. Furthermore using more and more "automatic" filtered pieces of information. Three Dimensional immersive views and ad-hoc three dimensional graphical cockpits, enhanced with audio, video and pictures, can benefits commanders of an increased speed and completeness of intelligence data visualization and collection that are not currently available to commanders and specialist in any sort of framework.

Thinking about specific operational contexts like CIMIC operations, it may be good to talk about the potential benefits of including civilians in this information gathering for the purpose of winning hearts and minds and discovering who provides trustworthy intelligence.

VOC framework in a crowdsourced virtual operation center, could be able to leverage resources (the virtual cross functional teams) creating self-synchronized relationship with subordinated parallel and upper level of command gathering the feedbacks and addressing responses as well as orders to the assigned units. Passing from the unity of command to what the authors consider as the "multidimensionality" of command.

Virtual worlds synthetic environment is one of the core technology the authors take in consideration to represent and operate a Virtual Command Post both at tactical and operational level.

Figure 2: Virtual Operation Center.

1.3. Interoperable Languages

In a complex real-time information environment the first requirement is comprehensible and unambiguous communication and representation of knowledge.

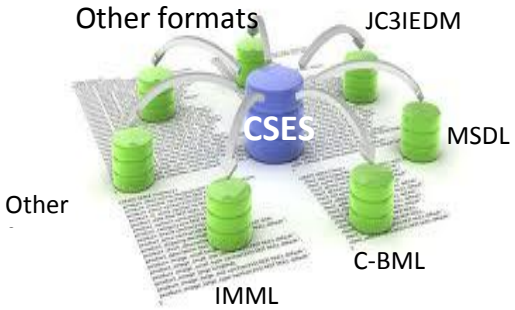

Figure 3: CSES Interoperable architecture

This is especially critical and difficult as the framework is suitable for use for multi-organizational collaboration (including joint, multinational, intergovernmental and interagency services), where people have to cooperate together remotely and cannot rely on common cultural reference points and assumed knowledge.

The need to develop a common operational language, that should be read and understood both by human beings, simulated entities and robots, has driven lots of applied research activities involving a large number of Scientists, Academia, Industry and Military personnel and Organizations. The most valuable results are the Military Scenario Definition Language (MSDL) and the Coalition Battle Management Language (C-BML). Both languages has started to be included in latest promising C2 and simulation technology and now they are under NATO development and under the SISO (Simulation Interoperability Standard Organization) standardization process. Both Languages share a common data base model the JC3IEDM (Joint Command, Control, Consultation and Information Exchange Data Model). This model is being ratified by NATO countries too under NATO 5525 stanag.

As the state of the art of these research activities the Coalition Battle Management Service (CBMS) is a technical infrastructure that enables the exchange of resources (orders, reports, and requests) between Command and Control (C2) systems, simulation systems and robotic forces. CBMS is a collection of composable web services that can be orchestrated to support the needs of a particular federation. CBMS is currently implemented as a service oriented architecture with an interrupt mechanism, a filtering mechanism and a data distribution mechanism that can be used to support the validation, storage, search and exchange of XML based languages.

Taking on consideration the state of the art of the development in this field the authors are investigating how C-BML and MSDL can be incorporated or implemented via or within a unique high level metadata xml schema to represent data coming from a C2 data model into a 3D Virtual World and vice versa. Furthermore, this metadata xml schema should align and bridge properties between both languages and above all it should make it possible to efficiently describe how related pieces of information can be visualized in a virtual worlds synthetic environment. A potential authors' solution is that it can be achieved by extending IMML.

IMML (Immersive Media Markup Language) is a lightweight 3D XML specification that is suitable for visualizing complex multimedia and interactions in a 3D space using a small amount of highly readable XML. IMML aims to be abstract enough that it can be used in conjunction with multiple devices and clients that use a range of 2D, 3D or Augmented Reality visualization as well as proprietary and/or open formats to render the scene on a device. It is also suited to receiving real time updates from external services and data feeds that drive the visualization. Finally, IMML is easily generated or controlled by other computer languages making it a useful markup language for an adaptive immersive web. By using IMML, all virtual world information and user input can be contained in an abstract metadata format that can then be rendered on the users' device to suit the users' diverse needs as they participate in a sharable environment.

Immersive Media Markup Language (IMML) is a specification that:

- Defines the positions of objects in 3D space, describing a 3D scene
- Is capable of capturing the changes in the 3D scene in the mark-up language
- Defines the interaction and use of different forms of media (3D, video, music, 2D images, text output, additional services such as VoIP, etc)
- Defines how objects interact in a multi-user (networked) situation
- Includes interactivity between elements and their re-use Includes the real world conventions means of interacting in a 3-D environment (e.g. physics)

- Supports extensibility through scripting languages and plug-ins that can define API interfaces within IMML

2. LVC SIMULATION, AUGMENTED REALITY AND THE COMMON SYNTHETIC ENVIRONMENT

The VOCF framework and its architecture look at the role of LVC simulation that is evolving and raising its fidelity level and introducing new trends and technology to maximize the effectiveness of military training. Using a unique C2 and Simulation framework implementing interoperable languages is possible to gain the maximum benefits, and effectiveness for training, support to operations and support to operational planning.

2.1. Live simulation and augmented reality techniques

Live simulation is increasingly using Hollywood's special effects, prosthetics on actors and realistic dummies (well known as trauma patient simulators) to be more realistic and test troop proficiency. The idea is to try to re-create and to instill to the training audience the fog of war effect within a hyper-realistic environment.

Augmented reality is the latest trends in robotics games and portable smart devices. Thanks to hi-tech innovation and microelectronics, HD cameras, gyroscopes, micro inertial accelerometers, gps, wireless communications, high memory and hi speed computational capabilities make things easier. What three years ago seemed a revolutionary game concept today is a promising high fidelity training system.

The Authors are investigating on what the possible use of Augmented Reality Techniques are and how applying them to live instrumentation for training purposes but also for maintenance activities. Furthermore how these techniques can be proficiently used in the following training fields:

- Information and evaluation support to live training augmentees and trainers. Using portable devices, like 10" tablets equipped with a camera, it is possible to visualize pertinent pieces of information about the ongoing activities. Simply aiming to units or to a fire range area it is possible to visualize objects and data synchronized with training event. It is possible to display units information, like status, tasks, ongoing exercise results and so on;
- Live weapon system training device. Embedding in optics and or pass-through display AR visualization techniques with a 3D Simulation Engine, it is possible to represent virtual objects and visualize training additional data (like scoring). Thinking about an anti tank missile simulator, using the real weapon system with an additional pass-through optics it is possible to represent 3D objects like vehicles, personnel and buildings. Furthermore it is possible to visualize the missile trajectory and then simulate the impact on the object, with the related blast effects on the 3D objects if hit by the operator;
- Live training system. Augmented Reality with IR-like miles system can be used to create interaction between the real and the virtual world objects. This is now possible creating a mixed reality environment where soldiers can be immersed in a real room. They are able to see real object as well as 3D virtual objects injected in the environment. Interaction between both types of objects is guaranteed by a complex tracking system, a virtual simulator and pass-through optics. A virtual soldier is then able to shot to a real one and vice-versa.
- Live maintenance training support and instructions. Using special AR techniques with special tags and portable devices it possible to detect equipments and their parts showing the instruction about maintenance actions to perform. It is possible to print on each part of an equipment, i.e. a car engine, in a find out position, a special tag or marker that is recognizable by the AR training application installed on a smart phone, a tablet, a wearable PC with AR goggles. When each special tag is spotted, AR application return displayed information about the spotted part. In addition should be possible to visualize its relationship with other parts, possible maintenance tasks to be performed on it, referral values if something to be tuned, the way to assembly or disassembly the part and so on.

2.2. Constructive simulation and IA-CGF simulators

Constructive simulation is widely implementing computer generated forces driven by intelligent agents technology (IA-CGF), in federated training simulation environments. The use of IA-CGF systems_to drive simulated entities automatically, made easy to achieve the reduction of the workforce (workstations' operators). Furthermore it makes possible to address special tasks and behaviors to particular simulated entities.

Regarding to Commander and staff training looking at a "traditional" Command Post eXercise Computer Assisted eXercise (CPX-CAX), it is possible to implement IA-CGF to step in Lowcon's. This is possible thanks to IA-CGF capability to parse Commander Intents, Orders, Task and Reports via Interoperable Languages like C-BML.

In addition implementing an Interoperable High Level language that includes MSDL, C-BML and other featured options is possible to enhance interoperability issues and to control simulated entities in a federated architecture.

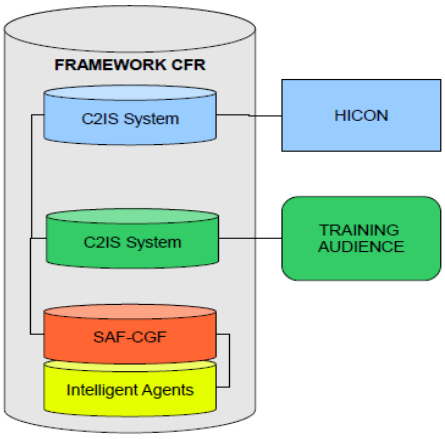

Figure 3: VOCF Conceptual Framework

2.3. Virtual simulation, Virtual Worlds and C2 environments

Virtual simulation is moving towards virtual worlds that provide 3D visual and audio experiences to create flexible immersive interactive training systems. Virtual Worlds technology can be enhanced by augmented reality techniques to support operational planning and operations execution. Using virtual worlds, virtual simulation can now provide:

- High fidelity 3D environments
- Complex behavior representation
- Urban & "life pattern" data;
- Distributed virtual collaboration;
- Potentials for multimedia overlays "inworld" that offer recent photo and video information for virtual recognition and mission rehearsal;
- Procedural modeling for areas that may lack high resolution imagery but have real or generated metadata. This enables near-real time generation of terrains and environments based on metadata.

  Given that virtual worlds can now essentially be generated in real time from data, metadata and imagery, it appears that virtual simulation can now have broader use in the C2 environment beyond just training.

  Referring to the NATO Training, Staging and Operational environments, there is an opportunity to use virtual simulation for Training, pre-deployment and mission rehearsal purposes.

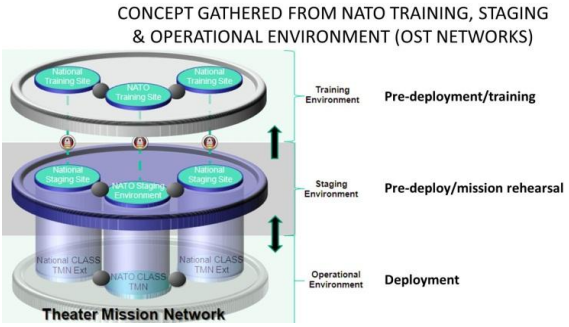

Figure 4: NATO Training and Staging Architecture

Once that is achieved, the final goal is the full digitization of the C2 environment so that a C2 environment can be run in part or whole as a virtual C2 environment where one or more staff participates in the C2 environment remotely.

The authors' VOCF concept for the broader use of virtual simulation adheres to the structure established by NATO doctrine for C2 training, staging & operational environment. To achieve a virtual C2 environment, existing network structures for classified information must be maintained. This means that the virtual C2 environment is part of the Operational environment which is a classified information environment running on a secure classified network and cannot be utilized as part of the Training environment. According to NATO doctrine, the Staging environment is also a classified environment and so it can receive snapshots from the Operational environment as teams prepare in Staging to move to Operations.

Benefits to a Training environment using distributed virtual worlds technology:

- Individual training (human interaction languages, tactics, tasks and procedures [TTP's])
- Collective /staff training (reproducing a virtual command post layout for C2 procedural training)

From the individual training perspective metaverse technology could offer to individuals training capabilities for human interaction languages and behavioral attitude. (E.g. the use of virtual worlds technology is demonstrated with effectiveness in training sessions to step up communication and behavior attitude using intelligent agent or remote role player that are able to interact with a real person or with its avatar).

The authors believe that there are significant opportunities to create effective training experiences especially when used for the purpose of collective staff training. The idea is to provide staff personnel access to virtual C2I training resources. These could be handled by real or emulated C2I service systems. The Authors imagine a virtual command post that offers an immersive reproduction of the real command post layout, where it is possible for the trainees to access the real systems used for training via the virtual representation of the same C2I systems. Through their avatars, staff personnel will be able to remotely interact and to collaborate together in a similar way to the real environment.

Thinking about the benefits to a Staging environment using distributed virtual worlds technology, the Authors' research outcomes showed that it gives:

- Greater flexibility on equipment access and support for remote team members with access to a connected network;

- High fidelity visualization of snapshots from the common synthetic environment that enable tactical assimilation and location recognition (e.g. virtual command center & virtual recognition)
- Mission rehearsal extended capabilities.

Mission rehearsal: in a distributed staging environment where operational data is gathered from the real environment "near real time or in an asynchronous mode", virtual world technologies offer several potential benefits including that the same tools used for collective commander and staff training could be used to prepare commanders and staff for real mission tasks during Staging, where they are able to access the real C2I systems with real mission data and where the real world command post layout and the Virtual Common Operational Environment (V-COE) are reproduced accurately within the virtual world environment.

Finally the Authors put in evidence that there is the future potential of creating a Virtual Command Post cloud infrastructure that actually supports part or all of the participants in the C2I environment acting remotely. This digitization of command may have significant challenges to face due to bandwidth restrictions and the potential for network outage bringing down the Operational environment but it also points to a much more flexible future where the systems for training and staging are the same ones used for operations, using a cloud computing architecture and supporting a crowdsourced environment.

3.4 Crowdsourced Mobile Application

In a generic (civilian) crowdsourced environment, the single actor is questioning and answering specific problems to solve.

In a governmental/military crowdsourced environment deployed in a humanitarian crisis or emergency and disaster relief operations, citizens should be both a resource and the judges of your efforts in national crisis response. The authors propose that providing a tool, it should enable citizens and joint forces to provide real time reports on what they know and to capture and upload multimedia such as photos to provide useful evidence of events. This tool, using different levels of secure access policies, diminish the volume of entry data and permit to operate intelligence activities, avoiding risks of counterintelligence and misinformation.

The authors approach is to focus on situations such as humanitarian crisis or emergency and disaster relief operations where citizens could play an active role to seek information, delivering them to authorities. The authors investigate also about a more specific military operation focusing on a military crowdsourced audience. This audience could help a commander, staff or analysts to solve in a better and fast way a specific operating problem whether as classical military situation or as a stability operation in a crisis response mission.

The flow of information using this technology can be computed and shared to provide to a Distributed Command and Coordination Center pieces of information that can be collected and visualized in a Virtual Immersive Environment.

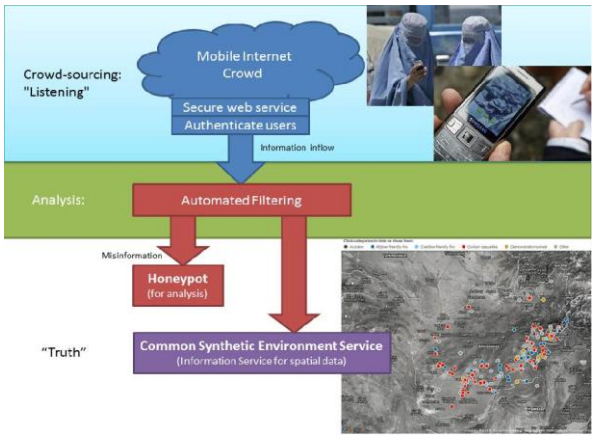

Figure 5: Crowdsourced mobile application logical Architecture.

The high level metadata language is the way to create a real interoperability layer between military and civilian information systems as the core language. The way to represent this information in a Virtual Common Operational Environment is described by, what the authors named, the "Common Synthetic Environment".

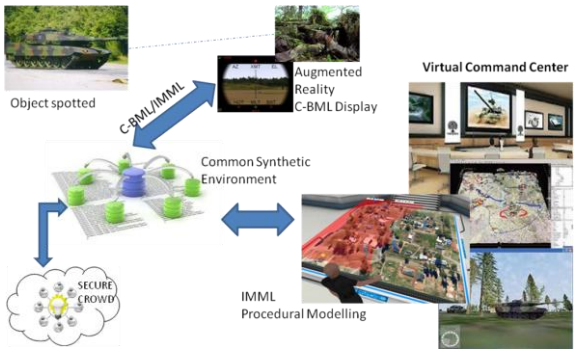

Figure 6: The Common Synthetic Environment Architecture.

3. CONCLUSIONS

LVC Simulation and Augmented Reality Techniques within a Virtual Operation Center Framework are a "bridge between the real and the virtual worlds described in a common synthetic environment accessible via augmented and virtual reality human interfaces".

The "Vireal" represent the way to combine virtual and real worlds into one synthetic multidimensional environment meshing the real world with the virtual one across interactive augmented virtuality and augmented reality techniques.

Augmented reality exploits the techniques of rendering the Common Synthetic Environment Virtual World entities/object, projecting them in the real world. Augmented virtuality exploits the techniques of

rendering the Common Synthetic Environment Real World entities/objects, projecting them in the virtual world. The "Vireal" represent the environment and describe the way how real and virtual entities/objects interact between them.

The authors demonstrate how the increasing role of hyper realistic LVC Simulation and Augmented Reality techniques, with the stimulation of the C2 environment supports the development of:

- next generation immersive-interactive training systems (vireal environment) dedicated to military individual and collective training in a LVC-AR IA the -CGF simulation environment with:
  - high fidelity immersive-interactive training systems;
  - C2 full duplex stimulation;
  - complex federated simulation architecture and complex scenarios;
  - extensive use of portable and mobile devices;
- next generation of C2 systems (Virtual Command Center) implementing virtual worlds technology, Interoperable High Level Metadata Languages, social network technology and cloud computing architectures with the integration of public information sources filtered for quality/misinformation

This research is opening new fields of application in the Defense and Civilian Domains. The development of a Common Synthetic Environment Service with the implementation of a High Level Markup Interoperable Languages within a mediation and exchange information system is the real challenge. Furthermore Virtual Worlds and Augmented Reality techniques for real-time rendering are the technology enabler for next generation of Command and Control architectures supporting a crowdsourced C2 organization in a networked distributed cloud computing synthetic environment.

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