NGN PLATFORMS FOR EMERGENCY

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PLATFORMS FOR CONTROL AND DELIVERY OF SERVICES TO BE USED FOR COMMUNICATION DURING CRISIS MANAGEMENT

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Abstract

Communication among rescue agencies involved in the management of emergency situations is a fundamental but critical topic for which they still miss effective and easy-to-use solutions.

The paper presents PICO (Platforms for service control and delivery in convergent networks) [MIUR - 2006] project results, aimed to the development of “innovative platforms for control and delivery of services in next generation networks (NGN)” proposing it as an innovative communication way to be used during prevention and management of emergencies situations.

The project dealt with the development of new telecom services to be delivered on large bandwidth networks, focusing on convergence between fixed-mobile phone networks by mean of IMS (IP Multimedia Subsystem) platform [Camarilli and García-Martín, 2006].

With the new proposed system, telecommunication services based on IT platforms are provided to different end-users for communicating during critical situations to prevent and/or manage emergency crisis. They would allow the establishment of communication channels that are not limited to voice, but may involve the use of ad-hoc designed applications able to enhance the flow of information exchanged between the caller (requiring the intervention of emergency) and the control room, to achieve the goal of an optimized association client - server able to exploit the full potential of both parties.

An experimentation based on IMS platform will be presented, focussing on how the complex IMS structure must be adapted and extended to provide a fixed access to fixed and mobile telecom operators. In particular it specifies the way for implementing a prototype analysing the features offered by IMS system for "context-aware" application streaming, and, in general, in remote applications usage by means of a virtual access to different protocols compliant with IMS system. In such a way, during the prevention and emergency management it would

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be possible to easily activate different services which would improve communication allowing data exchange.

Introduction

The management of crisis events, like natural and anthropic disasters, requires the simultaneous involvement of a large number of actors belonging to different agencies which are requested to constantly coordinate and interact, often even in very harsh conditions, or to supervise the situation ready to promptly intervene in case of necessity.

In such a variety of scenario, effective communication is a very crucial and strategic factor which still remains, together with the adoption and use of proper procedures, one of the key components from which it depends the good management of such events.

Emergency scenarios, especially those at large scales, need very reliable, robust and effective communication systems to enable all involved actors to easy coordinate and interact on field and/or with a remote command and control room. The use of innovative service control and distribution platforms, under the Next Generation Network paradigm, capable to provide advanced telecom services addressed to heterogeneous actors can strongly improve the management of these scenarios, exploiting the capabilities of Internet Technologies while providing new advanced services complementary to the traditional ones (voice).

In fact, through an adequate exploitation of the opportunities offered by IT, it is possible to establish communication channels, especially on large bandwidth networks, which are not limited to voice communication, but which involve the use of ad-hoc applications designed to enhance the flow of information exchanged between all involved actors.

Project PICO aimed to create innovative telecom services focusing on convergence between fixed-mobile phone networks and on technologies for service creation, provisioning, and management, for advanced and high added value service delivery. In particular the main project goal was the development and experiment of an innovative service on large bandwidth networks based on IMS platform, properly adapted and extended to provide access to both fix and mobile telecom operators. As specific goals the project implemented a sever prototype compliant with the features offered by IMS system for "context-aware" application streaming.

The paper illustrates in more details the features of IMS based PICO’s platform as a real example of an effective and advanced system to be used for communication during crisis management over large bandwidth networks.

After a general introduction to the PICO platform it will be presented the IMS architecture and the protocols for application streaming which have been used for the PICO demonstrator design. This last will be described in its main components which, in the context of IMS architecture, are identified in two different parts: the user device and the application server.

Finally PICO project results will be reported with the list of PICO applications used for the definition of typical use cases over which the prototype has been implemented and tested in a typical scenario.

Theory and Method

Introduction to PICO Platform

The design idea behind the whole PICO system is the development of a broadband innovative telecommunication system for a variety of applications in security, prevention and intervention in case of natural disasters. The project's objective is to develop and test innovative services in an IMS environment, in which the structure of the IMS platform architecture is adapted and extended to fit the context of work. In particular a prototype was implemented analysing the performance of the services offered by the IMS in terms of streaming application having context-awareness properties. More generically, the developed architecture allows, via remote virtual infrastructure, to access to broadband communication

applications based on the use of specific protocols while responding to specific requirements and verifying the compatibility of the end user characteristics.

The platform is set up by two different elements: the client and the server. Client devices are used by end users whereas the server is supposed to be in a remote location, not necessarily related to any specific involved end-user agency. As an example within the project, three entities engaged in the management of public safety were considered playing the role of end-users: Fire Fighter (FF), police (Law Enforcement, LE) and Emergency Medical Services (EMS) operators. Each single operator is defined as a PSCDU (Public Safety Communications Device User) which is the real user of the device.

IMS Architecture for PICO

IMS is a network architecture for deploying IP multimedia services enabling a multimedia experience richer than the circuit-based technology, creating a technology and terminals with multiple types of network access, geographical location of utilities and high customization of services according to the needs of end users.

The IMS technology is the key element in 3G and NGN (Next Generation Networks) architectures that merges the Internet with the cellular world. It makes possible to provide ubiquitous cellular access to all the services that the Internet provides, so that internet technologies, such as the web, email, instant messaging, presence, and videoconferencing can be available nearly everywhere. IMS fills the gap between the two most successful communication paradigms, mobile and Internet technology.

In PICO project the following IMS basic principles were considered:

- IMS enables access independence. This means that all existing networks could work with IMS, through appropriate gateways and interfaces, in order of the layer considered.
- IMS works with terminal and user mobility.
- IMS allows operators and service providers to use different underlying network architecture.
- IMS offers extensive IP-based services, such as VOIP (Voice over IP), POC (Push to talk Over Cellular), multiparty gaming, videoconferencing, presence information, instant messaging, and content sharing, and so on.

PICO architecture and prototype description

PICO system is composed by two different main elements:

- User device called Public Safety Communications Device (PSCD): a next generation device, which is the operators' equipment allowing the user to access the IMS subsystem and its services;
- Application Server called Public Safety Communication Server (PSCS): an application server that belongs to the IP Multimedia Subsystem, and performs the functionalities of authentication and authorization of users based on their profiles, mobility handling, application on demand handling and many others.

To be effectively used, both PSCD and PSCS must be authenticated by IP Multimedia Subsystem and communication is based on SIP protocol [Rosenberg, J., et al., 2002], [Roach, A., 2002], [Niemi, A., 2004], [Rosenberg, J., 2004], MSRP protocol, ConteXML.

The server platform fulfils several key issues for guaranteeing efficient communication operability: connection speed, interoperability, functionality, security operations, providing high-bandwidth to allow the transfer of multimedia content.

Similarly, also devices have a series of specific features: they must have different interfaces to suit users who are using them and to interact with existing communication systems, and must be resistant to environmental conditions, often very harsh. In addition to user devices, it is possible to assume the on-site presence of several sensors, whose job might be tracking

weather, monitoring of risk areas, measurement of vital signs of rescuers, and so on. All devices in use, however, must be able to interface with the selected NGN platform.

As a general procedure the system requires that any user with a PSCD (PSCDU) which allows him to communicate with the central assistance center must make a specific procedure on authentication apparatus. During the authentication and identification phase the PSCDU provides the server with information related its own category, so to be filed in accordance with his/her profile which enable him/her to access to specific sub-set of data. This operation is done also assuming a hierarchical organization of the networks. Figure 1 shows examples of elementary operations that a public security user can perform: Authentication, Identification, Selection of the requested application (chosen from a list of applications available in streaming from the operations center), Execution of the selected application, Removal of the application once finished its use. The removal of the application is made to avoid unnecessarily occupation of the device memory.

Figure 1 - Basic actions using a PSCD

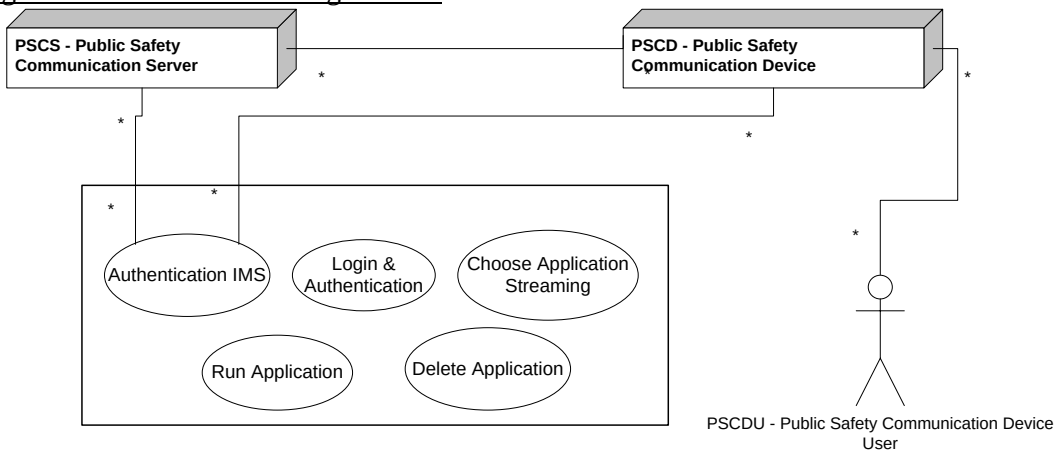
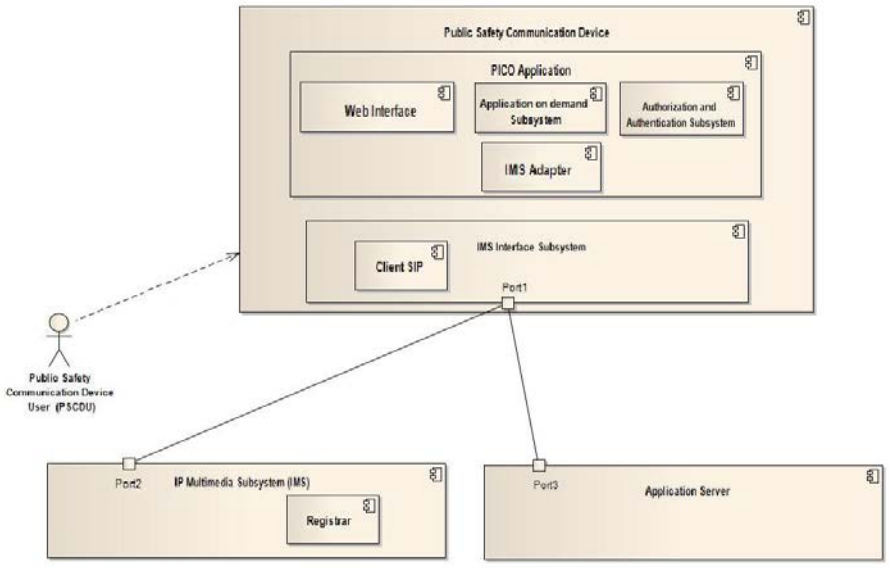


Figure 2 shows an overview of the system logic architecture. The PSCD is composed of two main parts: the application components and the IMS application interface needed to interact with the system. The application part includes the web interface used by the user, the system for managing on-demand applications and the authentication and authorization block.

Figure 2 – System logic architecture



Interface contains the real SIP client, which is related to the Application Server (the database that contains all the applications accessible by the user) and to the IMS platform, which manages all communication parts like: system registration, calls routing, etc. The protocol used by IMS and SIP. Both PSCDUs and the operation center interface with the IMS platform, respectively by mean of the PICO device (PSCD) and the PICO server (PSCS).

The PCSDS is an application which performs an IMS registration and is considered in the system as a Robot. All PSCD users using a PICO client (extended IMS client) are registered to the IMS as well for the geographical area pertaining to the PICO server. Each user has PICO robot (PSCDS) as buddy and periodically sends its context using MSRP protocol and the IMS-SIP session. The context is a XML File (ConteXML) which contains several contexts information such as user location, battery level, disk usage, type of user and so on. PICO Server processes the context of all users in a specific area and also analyzing the context of emergencies, it performs reasoning to offer or send relevant context application.
PICO server (PSCDS) uses a rule engine (Reasoner) and some preset rules to perform his actions. The application are exchanged, organized and installed using the MSRV protocol and this extends the IMS platform with full application support.

Public Safety Communications Device (PSCD)

A PSCD is a generalization of a particular device for each type of involved use; it is a next generation device and it must have additional equipment to perform advanced multimedia required services, like at least a video camera to perform videoconferencing and allowing recording user sights occurred during his presence, a microphone to perform audio calls or a GPS device to perform the geo-location.

Moreover, the device could have an additional subset of sensors in order to perform registration of vital parameters, for example the EKG unit, a respirator monitor, and a blood pressure monitor so that, for example, a paramedic operator can monitor vital signals but also analyze blood and chemical air composition, or also substances that intoxicated the patient. Also streaming is helpful because, in case of need, the paramedics could enable the plug in for streaming, for analysis purposes. Devices transmit with an application server belonging to IP Multimedia Subsystem; the server manages all the information regarding the different users of the system, profiles, resource access grants, and allows the authenticated user for download of an application among the downloadable set.

A logical view of the PSCD is described in Figure 3, which identifies five main blocks (or subsystems):

- IMS client, responsible for implementing all the IMS client features required by the PSCD. Most important IMS features here supported are user authentication to the IMS, audio/video call setup, presence service and IM. More generally, the IMS client manages all the multimedia sessions required by the PSCD; it exports a proper set of APIs to the other PSCD subsystems and implements the MSRP protocol to allow file transfer. It provides the application transfer from PSCD Server.
- Base Features, which is the core of the PSCD
- User Driven Applications. This subsystem collects all the applications required by the PSCD during operations and that are specified to the user profiles and needs
- Device Driven applications which groups all the applications required during operations by the PSCD and that are specific for the device type and the application installed on it.

Each User, after IMS authentication PSCS authorization, reaches his own home page where he/she can choose the Application On demand to download.

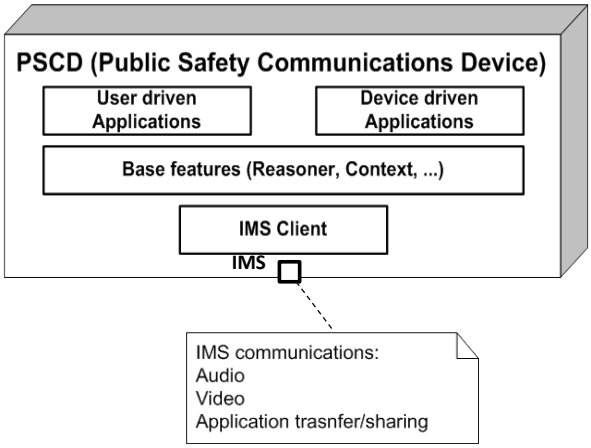
The PSCD is an extended IMS Client and provides all SIP functionalities such as:

- Audio call
- Video call
- Chat

- Application transfer (file transfer)

This type of communications can be established among users or between PICO client and PICO server.

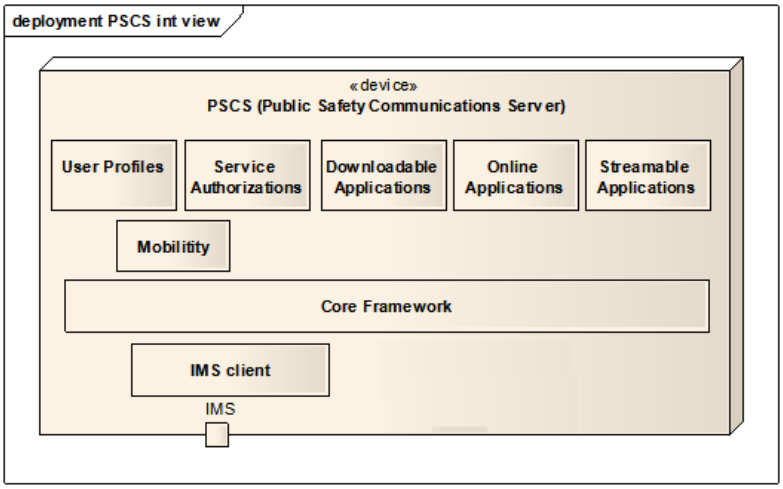
Figure 3 - PSCD internal view



Public Safety Communication Server (PSCS)

The PSCS is the server of the PICO demonstrator which enables the PSCD to access to the PICO services and applications. PSCS can be considered as an application server of the IMS but can be also identified as a client of the IMS with special functions. Figure 4 shows the internal view of PSCS. It is made up by the following different elements:

Figure 4 - Public Safety Communication Server



- User Profile: all the users have a user profile that describes the configuration for a specific user, including the user's access permission for the applications on demand, the user type (FF, LE or EMS) and preferences settings.
- Service Authorizations which sets authorization for the required service at user level.
- Downloadable Applications: these are the downloadable applications on demand.
- Online Applications: these are the applications on demand that are directly on line when the user perform authentication.
- Stream Applications: applications that can be streamed on demand.
- Mobility this module manages mobility among the three IMS architectures (FF, LE and EMS Network).
- Core framework: this module performs all the basic functionalities.
- IMS client: this module performs the functionality of IMS client allowing: registration on IMS, invite a session, file transfer using MSRP protocol and so on.
- Reasoner: this module performs reasoning based on rules that consider emergencies for

a specific area and all users near that area.

- Context: this module manages all Context parameters based on (GEO Coordinates of the PSCD Users, the battery level of the device, network traffic and so on

PICO Applications

PICO platform is application centric allowing each operator to access a set of application customized to his/her own profile, depending on its belonging entity cluster.

In a scenario of IMS Internetworking for each category there is a different IMS networks. In the PICO example there is one for FF, one for LE and one for EMS and each user has its home network and Server. When in the location of the emergency scenario not all the three networks can be reached, the user can connect through the home network of one of the other present actors, after authorization and authentication by this last server. Another aspect to be managed in an application-centric network is the context of application. Assumed that the framework is extended for the application sharing (actually is one of the goals of PICO), the operating system should handle the applications that could be installed onto device. Many are the contextual parameters that could be analyzed for each device when an application starts downloading.

Applications On Demand

For what it concerns the application-centric network, one of the goals of PICO was to assume that the framework is extended for the application sharing so that the operating system handles the applications to be installed onto device. Many are the contextual parameters that could be analyzed for each device when an application starts downloading, for instance disk usage, location, battery level and network traffic.

Considering these parameters, an application could be downloaded or not, or in case of low disk space, a lite version of an application could be downloaded instead of full version, or an application with less media usage instead of full media in case of low battery/bad network.

Besides these assumptions, PICO takes care also of more context parameters such as user account and privileges, existing emergencies in a geographical area, status and proximity of neighbors (Paramedics, FF and Police)

In the project PICO example scenario, three classes of application were considered, specific for type of user (EMS Applications, LE Applications and FF Applications), to be selected on demand, when necessary, and then downloaded and run locally. Furthermore also common classes can be considered to be shared by all the users like Workforce, Incident Command and On board resources status.

Test scenario

As an example of concrete applications the emergency related to a car accident in urban area has been developed. Three cars have an accident with the effect of having three unconscious injured. A policeman reaches the accident place and on his device appears the list of buddies and his position in that moment. From it he selects the operator of the police station and begins an audio call using an IMS Client. Meantime, via a web interface the operator inserts all initial data about the accident into PICO Server while the policeman launches the first emergency call application and starts scanning the QRCode of the first victim to identify them.

The QRCode provides a pop-up message with the name and last name of the victim and calls automatically the first number of an important person (i.e parents) using the IMS Client. At the same time, the application using the information embedded in the QRCode, sends the name and other important information related to the victim to the nearest PICO Server available using LoST (Location-To-Service Translation Protocol) protocol. Moreover all Accident information such as name and current location are also sent to victims important facebook contacts. PICO Server processes the information related to the accident and the

information related to all users' contexts connected to the PICO Server. An ambulance with two paramedics near the accident zone is alerted by the PICO Server via the Reasoner with a message. The paramedics' device that contains all medical information gained on the accident place by the policeman using the embedded IMS Client, automatically connects with an audio call or video call the paramedic and the policeman.

Meantime, the policeman manages also the removal of the cars. From the contexual application list he starts an application to find the nearest tow truck to the zone and sends a SMS with all accident details (location, number of cars, and similar information).

A squad of fire fighters is in a near zone attached to a different PICO. Through the Server connection a request for availability to intervene is forwarded the squad, using LoST, from a PICO server to the other. PICO Server starts the application that shows the best path to the FF and begins also a communication session between the FF and the policeman that, based on network condition, can be a chat session (low traffic condition also with all accident details), audio session (medium traffic condition) or video session (high traffic condition)

The policeman having different set of data available decides to share a picture using a IMS session to the FF because a small fire was started after the accident. So the FF can see how big is the fire and position of the cars. Meanwhile an update about the ambulance appears on the desktop of the policeman device based on his context. Finally, a notification message on the device alerts the policeman that the contextual application list has been updated, so the policeman can switch the desktop, selects the First Aid Application (or PDF file from third desktop) and download/launch it. When the ambulance arrives to the accident place, the paramedic selects from the contextual application the list the application to monitor the heart rate of the victim and rescue activities start.

PICO technologies

PICO uses several technologies. PICO server is a JAVA EE application which uses PostgreSQL as database to collect all information related to the PSCD Users and Emergencies for a specific area. As Rule engine, PICO uses Drools from JBOSS. It takes some rules as input and provides the best action to do for each user, for example, a relevant application in case of emergency or an audio/video call to other PSCD User etc.

As IMS framework (server side), PICO uses *doubango* which is a 3GPP IMS framework for both embedded and desktop system. It is written in ANSI-C and so is very powerful. It exposes a Java wrapper to allow communication with the PICO JAVA EE application. PICO client is the mobile application written in JAVA and converted by Dalvik machine for Android system.

As IMS framework (client side), PICO uses *imsdroid* which in turn is based on *doubango* as well. PICO extends its capabilities for full application support.

As operating system PICO uses Google Android a software stack for mobile devices that includes an operating system, middleware and key applications. The actual version of Android SDK is a beta version; it provides the tools and APIs necessary to begin developing applications on the Android platform using the Java programming language.

User interface and visual design

With PICO some guidelines have been defined for the user interface development. Essentially on the mobile application there are three main desktop, or three main applications.

a. Main Desktop. It is the main desktop for the PSCD which contains all useful information related to the emergency. It consist of Status Info Widget/Box with Emergency details, Buddies List which includes Operator + other buddies associated to the emergency and Map with the location of all PSCD Users and/or best path available to reach the Emergency.

b. Second Desktop. It contains the contextual application list, installed or to be installed, or previously installed applications or not installed applications which will be linked to allow the download of them.

c. Content Desktop. It contains file list with useful contents to PCSDU (i.e PDF, Images, …).

Moreover all notifications to the PSCD users have been delivered through a notification area on top of the main widget using SIP/IMS messages.

Results

The paper intended to demonstrate the effectiveness of IMS system to manage riche communication even in very harsh conditions, allowing actors involved in the response activities to use a number of potential application customized and generalized which can improve the management of critical emergency situation, through the access to data and tools, for the moment not available with traditional available systems.

PICO system demonstrated that during a crisis scenario is possible to access and use:

- A context aware presence, by using the IMS protocols, in order to have the opportunity to see and interact with the end users present on field and involved in rescue activities
- An intelligent communication system based on the context awareness (i.e. battery status, end user profile, and other similar) elements accessible via IMS
- Customised applications, selected for a specific crisis scenario, which are accessible by mean of the MSRP protocol and which can be later deleted once the crisis will be over
- Different protocols like ConteXML to define the context.

Discussion

The flexibility and dynamism of PICO platform can pave the way to a new paradigm of managing emergency and crisis scenarios, by the access to a variety of applications devoted and customised to the specific situation depending on the interested scenario. The use of IMS platform enables to bridge telecommunication and Internet world, opening a huge amount of potential field of applications, which can be used by operators on field, with high flexibility and simplicity of access.

The platform and its relevant protocols are now in a prototype version already tested in laboratory simulation of different scenarios as the one previously described. Field trial application would better validate the achieved results, verifying in real time conditions the effectiveness of the system under the applicative and communication perspective. From the project results and the potentialities the system has, it is evident that PICO platform solutions and applications can realistically give a big boost to the crisis scenario management, if the related infrastructure, as described in the present paper will be accordingly deployed.

As a follow up further development are possible both for improving the already existing protocols and clustering and integrate new protocol as, for example LoST, a protocol for mapping Geographic locations to public safety answering points.

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