



The Role of Geographic Information Systems in Next Generation 112

Moving from current state 112 to future state NG112

The Role of Geographic Information Systems in Next Generation 112



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In the future, there will be different sources of location information available and accessible...

1. Executive Summary

Geographic Information Systems (GIS) have been widely adopted in emergency services over the past two decades. Besides full-blown software suites covering every potential area and use case with a need for geographic information, there are also more lightweight systems available on the market that are more purpose-built for use in emergency services PSAPs. These focus on the special purposes for 112 emergency communication, and even freeware e.g. Open Street Map or Google Maps services are used, as requirements often do not go beyond understanding the precise location of incidents, not asking for the use of large-GIS suite features.

In any case, with NG112 the process of how to use GIS might change, as more and more communication services are envisaged to come with attached location info. Today, very often precise caller localisations are still derived manually, or derived from network-provided location, enhanced by information gathered through the emergency call in order to be precise enough.

In the future, there will be different sources of location information available and accessible. The key difference to today's emergency calling can be seen in the availability of location information immediately attached to the incoming emergency call in one form or another.

Therefore, Location Information Services and Location Validation Services will become more relevant, as a concentration point of multiple service- and communication-related entry gates.

This document summarises the current state of GIS with ISDN before looking into its future state with NG112. In addition, this document provides a thoughtful approach to how GIS and NG112 potentially show capabilities in changing procedures and roles in the end-to-end emergency response process.

GIS help to geo-tag an incident, understand the situational context, and relate incident and response in a meaningful way.

2. GIS and Emergency Calls Today

From Wikipedia¹:

A "Geographic Information System (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data. [...]

In general, the term describes any information system that integrates, stores, edits, analyzes, shares, and displays geographic information. GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations.[...]

GIS can refer to a number of different technologies, processes, and methods. It is attached to many operations and has many applications related to engineering, planning, management, transport/logistics, insurance, telecommunications, and business.[...] For that reason, GIS and location intelligence applications can be the foundation for many location-enabled services that rely on analysis and visualization.

GIS can relate unrelated information by using location as the key index variable. Locations or extents in the Earth space–time may be recorded as dates/times of occurrence, and x, y, and z coordinates representing, longitude, latitude, and elevation, respectively. [...]

Geographic Information Systems (GIS) are a key application to emergency response organisations nowadays, helping them to geo-tag an incident, understand the situational context, and relate incident and response in a meaningful way. GIS systems are very often a functional extension to Computer Aided Dispatch (CAD) systems, connecting case management with geographical information.

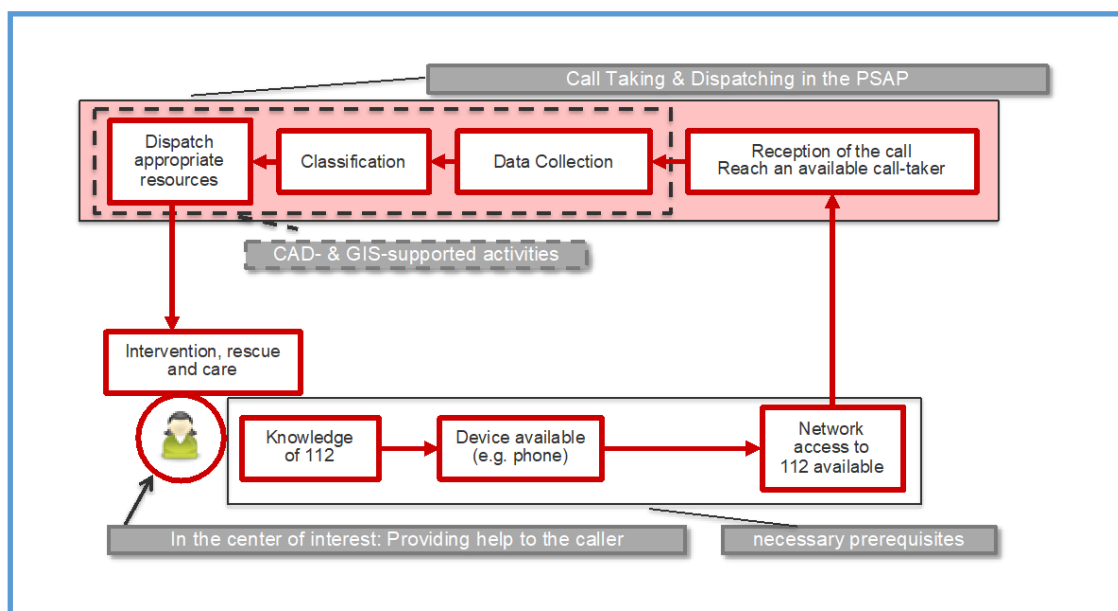
¹https://en.wikipedia.org/wiki/Geographic_information_system

There are two steps where Geographic Information Systems are most likely to deliver value...

2.1 Introduction: GIS and the emergency service chain

Before stepping into the details of emergency calls and the associated geolocation aspects, there should be a quick reference to where in the emergency call chain location-related information is needed.

The following picture describes the emergency call chain with special attention to the steps executed within the Public Safety Answering Point (PSAP):



Between receiving and answering the incoming emergency call and dispatching the appropriate resources, there are two steps where Geographic Information Systems are most likely to deliver value:

Data Collection

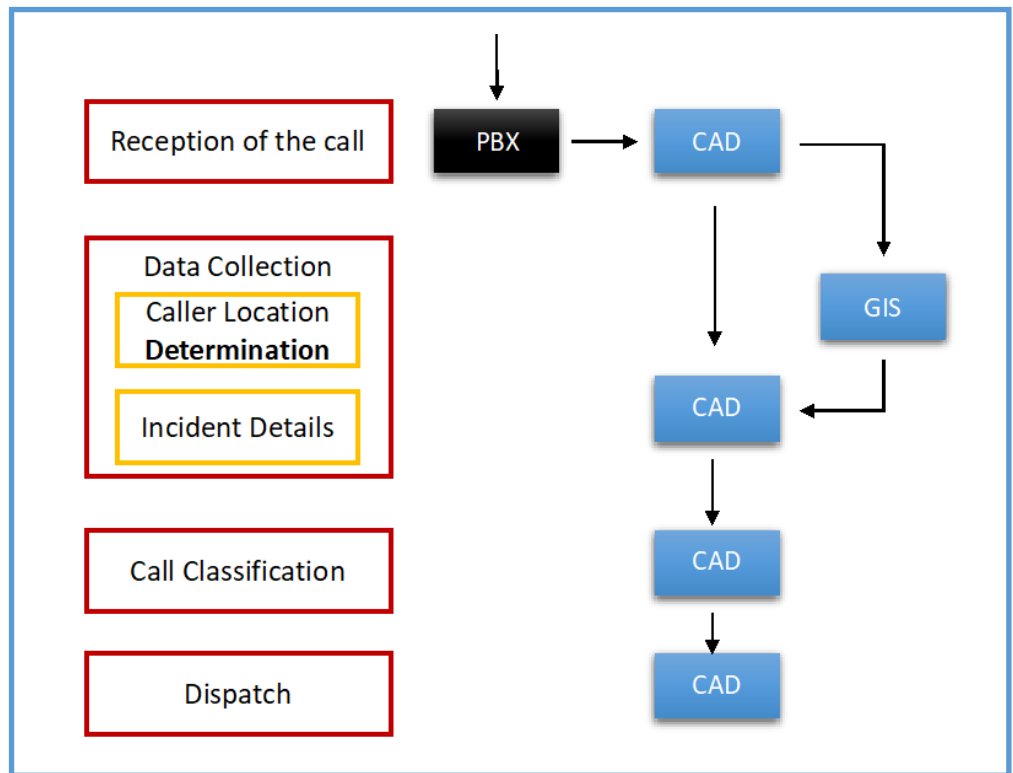
Location data is key to be fully understood in terms of where the call has originated from. In order to fully understand the context of the call, access to GIS with additional insight to the surrounding environment of the call adds to significantly increase situational insight.

Classification

In order to make an informed dispatching decision, the call and especially the emergency situation needs to be classified and circumstances have to be understood. Data collected in the previous step, enriched by additional data coming from a GIS system, can help to drive a precise classification.

In terms of precision regarding the location data, there is a need for the call taker either to verify the location throughout the Data Collection, or even to raise precise location data as part of the procedure by asking the caller, ultimately to generate a "dispatchable address" to send the responders to.

The following picture is aiming at associating and allocating the tasks "Call Reception", "Data Collection" with sub-tasks "Location Determination" and "Incident Details", "Call Classification" and "Dispatch" to the technical environment of Communication Subsystem (Telephone System PBX) and Information Subsystem (CAD and GIS):



The call arrives at the PBX, the calling party number as well as eventually the available location information is handed over from the PBX to the CAD system (in an ISDN-world typically by means of Computer Telephony Integration CTI). In the next step the call taker needs to deal with determining the caller's location (seeking support from the GIS's maps) **and** collecting the incident details from the conversation with the caller, managing the CAD system and - once determined and data entered - seeing the location in the GIS, before proceeding to the final tasks of case classification and dispatching again on the CAD.

In many current installations the Communication Subsystem and the Information Subsystem are merged into one product or solution with proprietary hardware and software, built exactly for the purpose.

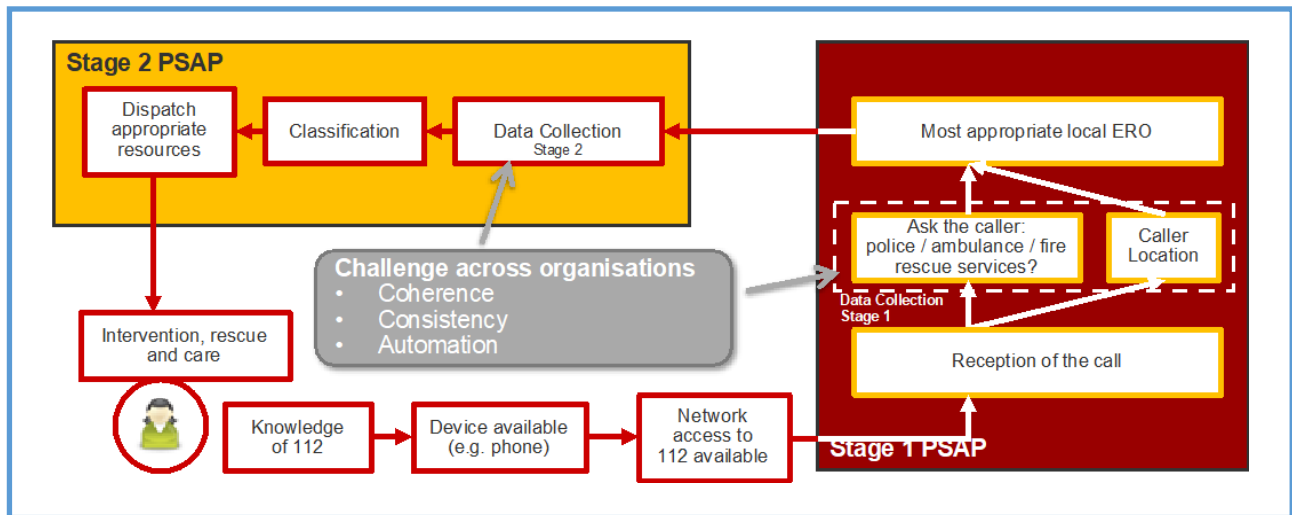
A full overview and discussion of the 112 emergency call chain can be found in the EENA document "112 Service Chain Description".²

The following paragraphs are going to describe two well-known PSAP implementation models, splitting "Call Taking" and "Dispatching" into separate organisations, showing the effect on GIS-related workflows as well.

²EENA Operations Document "112 Service Chain Description" http://www.eena.org/uploads/gallery/files/operations_documents/2011_06_10_112_service_chain_description.pdf

2.2 Emergency service chain in a 2-stage implementation: "Call Taking" and "Dispatching"

Depending on the local organisation in a country or region, the model to execute the end-to-end service chain from raising the emergency call to the arrival of the intervention team onsite, this process is likely to be split between different organisations, as shown in the following graphic:



As shown in this example based on an end-to-end process spanning two stages, data collection might be split across two organisations:

- Stage 1 PSAP: answering the emergency call, identifying the location, and determining which emergency service is required to respond to the case.
- Stage 2 PSAP: classifying the call and making a dispatch decision, supported by further collection of data.

Collection of data in stage 1 and stage 2 is likely to be of different depth and detail, according to the tasks to be fulfilled at each stage.

At stage 1, determining the caller location is mainly to understand the coarse geographic area of the caller, helping to identify the most appropriate Emergency Response Organisation (ERO). Once that is achieved, the call is forwarded to this respective ERO.

At stage 2, there is a need for more precise data (including location data), and to work with that data, analysing and assessing the operational picture given by the caller and other sources of information in order to come to a dispatching decision.

The challenge: splitting the geography-related process steps and data across 2 separate organisations...

Based on the example of this 2-stage process across multiple organisation the requirement of passing the data collected at stage 1 alongside the call to stage 2 becomes visible in order to maximise the efficiency of the end-to-end process.

The challenge in terms of **data coherence**, **consistency** as well as **process automation** arising from the 2-stage model (compared to a single stage PSAP implementation) lies in splitting the geography-related process steps and related data across two separate organisations. Many countries are following the 2-stage model, but not all are providing integrated processes solving these challenges.

Looking into this model from a GIS perspective, there could be two different types of GIS software in use in stage 1 and stage 2:

GIS for stage 1 PSAP:

more lightweight GIS system, focusing on location information only to determine the caller's location

GIS for stage 2 PSAP:

more complex GIS system, giving access to more advanced data and context on the location information received from stage 1, supporting dispatching and mission management, especially in terms of special resources needed for a specific environment at the determined location

A full overview and discussion of the 112 emergency call chain can be found in the EENA document "112 Service Chain Description".³

³ EENA Operations Document "112 Service Chain Description" http://www.eena.org/uploads/gallery/files/operations_documents/2011_06_10_112_service_chain_description.pdf

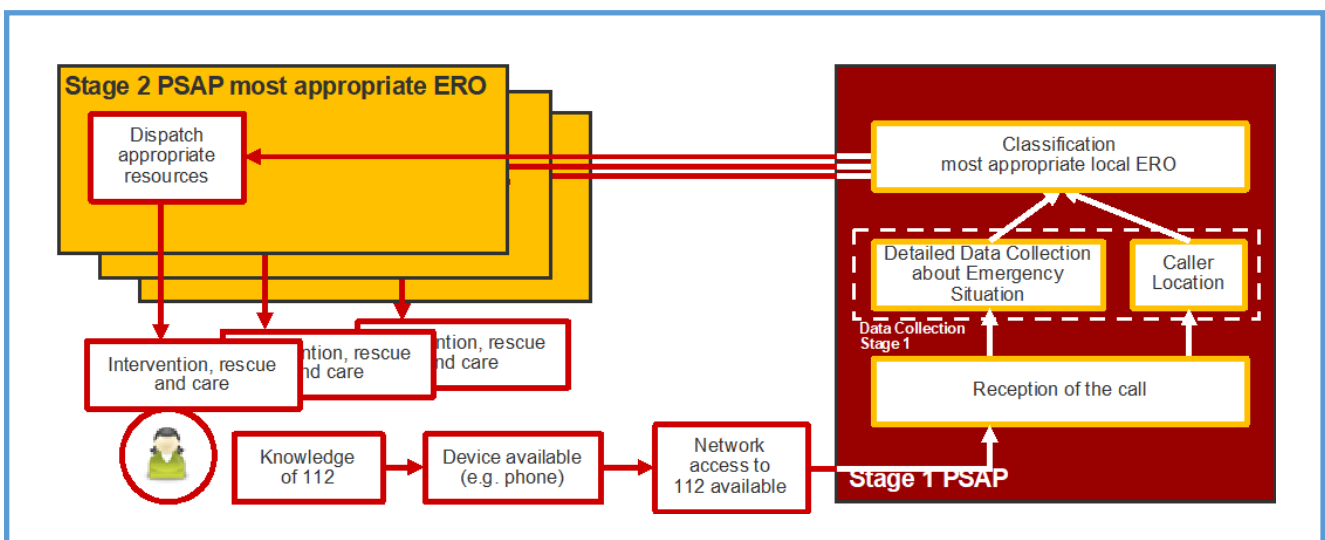
How to add the dimension of inter-agency collaboration and coordination?

2.3 Emergency service chain in a 2-stage implementation with "Parallel Dispatch"

Another 2-stage PSAP implementation model is known as "Parallel Dispatch". In this case, call taking at the Stage 1 PSAP results in the call taker classifying the incident and making a decision on the most appropriate local Emergency Response Organisation and the handing over the case for final local dispatch of responders.

The detailed data collection in this case is in the responsibility of the Stage 1 PSAP, and requires handover to the Stage 2 PSAP.

In case of a required multi-agency response, the handover needs to be repeated according to the number of involved EROs.



The specific challenge here is to add the dimension of **inter-agency collaboration** and **coordination** to the challenges already describes in the simple 2-stage model.

Visual overviews related to geography are key in order to manage large incidents...

3. Integration aspects between call data and GIS in the current context of ISDN networks

Understanding the different PSAP implementation models mentioned in the previous chapter, it is useful to explore the integration aspects of call-related information and data, forming the operational and situational context.

Visual overviews related to geography are key in order to manage large incidents, a map-based view to understand the full scenario is of great help to decide and coordinate the response.⁴

When a call to 112 or any other emergency number is processed in a Public Safety Answering Point (PSAP), the very first question that has to be answered by the caller is "Where is the emergency?".^{5,6} Localisation of the incident is of highest priority before stepping into further incident classification and dispatching appropriate resources to respond to the case.

Quite frequently, this very first question is difficult to answer by the caller due to the severity of the situation and the resulting confusion. In order to support a quick localisation and to speed up the call taking process, there has always been a high interest in leveraging call-related data available with the incoming call and thus supporting or even automating the next steps to follow.

This chapter describes the main location mechanisms related to emergency calls today in a communication network environment built on ISDN:⁷

1. use of the Calling Party Number (CPN) transmitted with the emergency call in order to lookup the address in a database
2. embed location information into the ISDN signaling and transport this information through the telephony system (PBX)⁸ of the PSAP

⁴EENA Operations Document "The Value of Spatial Information for Emergency Services" http://www.eena.org/download.asp?item_id=223

⁵EENA Operations Document "Call taking procedures and data to be gathered", http://www.eena.org/uploads/gallery/files/operations_documents/2012_12_03_calltakingproceduresanddatatobegathered.pdf

⁶EENA Operations Document "Using and optimising GIS in an emergency response" http://eena.org/download.asp?item_id=123

⁷ISDN: Integrated Services Digital Network, technology used by service providers from the late 1970s onward

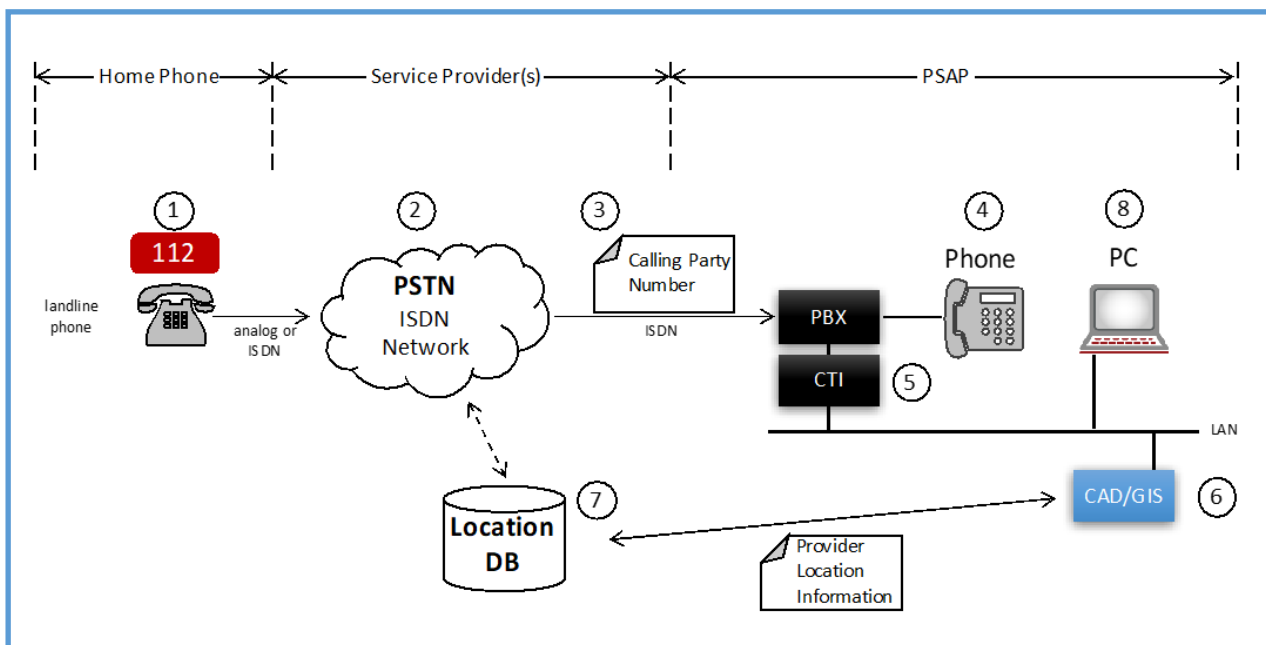
⁸PBX: Private Branch Exchange, a telephone system in a private network

3.1 Caller Location representation for landline originated calls

The first approach to automate location lookup became possible with the introduction of ISDN as a technology for the Public Switched Telephone Network (PSTN). This digital network technology first allowed additional information to be embedded into the call signaling between the service provider's network and the PBX system of the PSAP connected to this network to receive emergency calls.

The emergency call is raised from a landline phone (1) and is routed through the PSTN (2), operated by the Service Provider.⁹ Service Providers typically maintain databases that contain the civic address data associated with the telephone numbers and the telephone lines connected to their network. These databases are mainly used for billing purposes, and are updated in longer intervals (non-real-time).

When the call is handed over to the PBX system of the PSAP, the Calling Party Number (CPN) is transmitted (3) in the signaling channel of the ISDN link (D-Channel). The call is then picked up by a call taker, showing the calling party number in the phone's display (4).

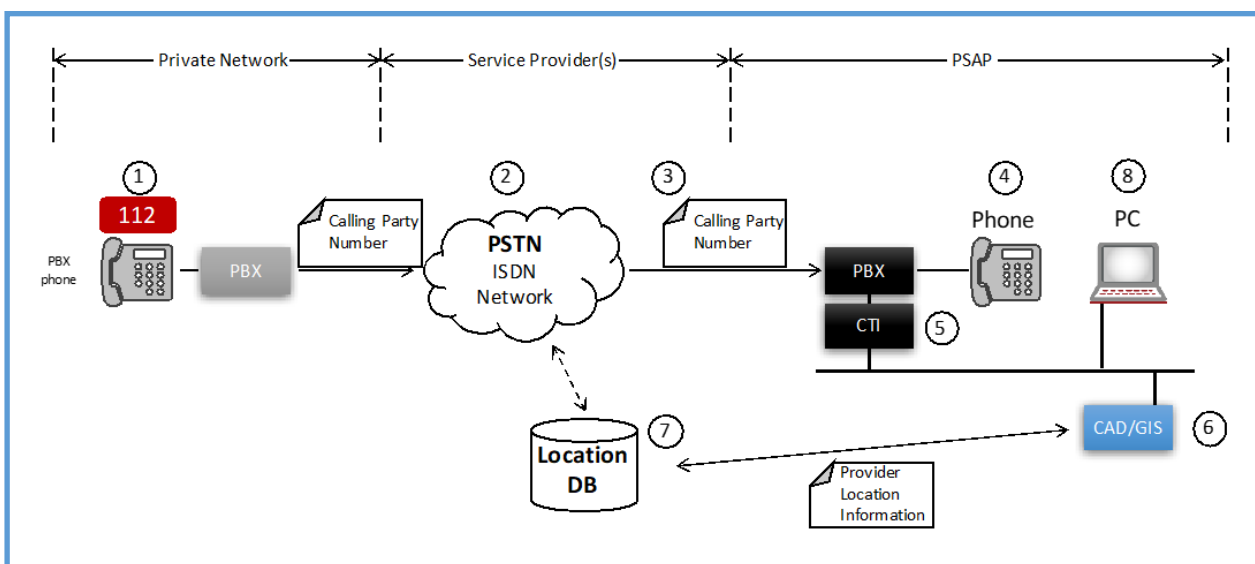


⁹In fact there can be one or more service providers involved into call routing from end to end.



In a second step, the connecting element between the PBX and the CAD/GIS applications of the PSAP, the so-called CTI¹⁰ server, hands over the Calling Party Number to the CAD and GIS system (6). Usually the CAD system allows the use of the CPN as a reference for a request into the service provider's address database (7). The result of this database lookup is the Provider's location information, which can then be presented at the call taker's desktop PC in the CAD application, as well as geographically positioned in the mapping software of the GIS (8).

In principle, the same procedure also applies to calls originated from a company's private network through the company's telephone system (PBX).



The difference between a standard call from a landline phone lies in the use of a PBX at the originating side of the call (1). A PBX usually holds multiple phone extensions, so not a single calling party number, but multiple ones that reside within the PBX's internal database, as well as in the Service Provider's Location Database (7).

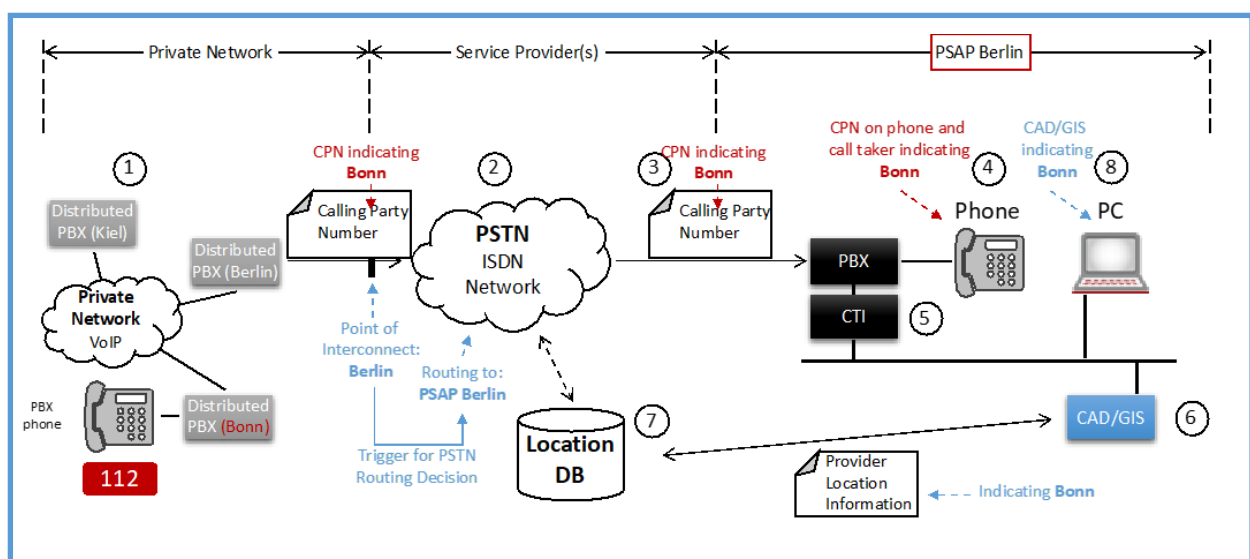
¹⁰CTI: Computer Telephony Integration, an infrastructure element translating between the software of the PBX and 3rd-party applications in an attached Local Area Network (LAN)

From the service provider's perspective there used to be only one civic address associated with all extensions that were administered on the company's PBX. In the days of ISDN PBX systems this was perfectly fine, because the one address was representing the location of the PBX system.

Since the early 2000s, the ISDN technology on the company's PBX system was replaced more and more by a technology called "Voice over IP" (VoIP)¹¹, which led to a single telephone system to be distributed across multiple locations, campuses, regions or even countries, with different civic addresses. So in many cases the civic address as an entry in the service provider's database is no longer accurately reflecting the true location of the phone.

The civic address in the service provider's database no longer accurately reflects the location of the phone...

The following example shows a Distributed VoIP-PBX system in Germany, covering company sites in Berlin (Headquarters), Kiel and Bonn (1). The connection between the Private Network and the Public Network is located in Berlin. The emergency call is raised from the company's site in Bonn. In a typical ISDN scenario, the PSTN Service Provider might even be seeing an emergency call with a calling party number from Bonn, but as the physical point of network interconnect is located in Berlin, the PSTN routing decision will result in forwarding the call to the PSAP responsible for Berlin (2).



¹¹EENA Technical Document: „The fundamentals of Voice over IP“, http://www.eena.org/download.asp?item_id=232

3.2 Caller Location representation for mobile originated calls

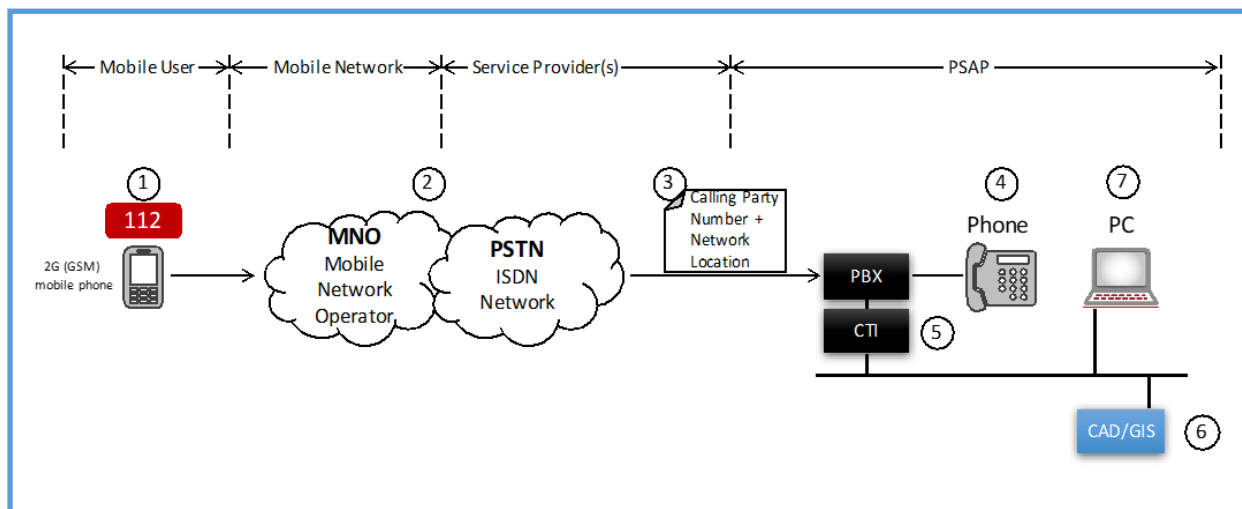
Comparing landline and mobile originated calls, the main difference is visible immediately: whereas in the PSTN based on ISDN technology geographic numbers have always been a given, there has never been a unique geographical association of mobile phone numbers, due to the definition and the nature of mobile communication.

With the advent of mobile networks in the 1990s and the wide adoption of mobile phones amongst the citizens in the following years, there was a need to establish other mechanisms to describe the location of origin for mobile originated emergency calls, still fitting into the technical concept of ISDN.

The solution here is to utilise the well-known location of a fixed network element, close to the true location of the mobile caller, which is the Radio Base Station (RBS) and the antenna of the RBS that are picking up the mobile call from the "air interface" (1) and conducting it to the "wired part of the wireless network".

So when the call is handed over from Mobile Network Operator's domain to the PSTN Service Provider's domain, the information on the geographic location of the Radio Base Station is passed within the SS7 protocol.¹² Further on, this location information is then matched towards the geographic areas of emergency call origination that determine which PSAP the call shall be handled in.

At the interconnection point between the PSTN and the PSAP, this information can be included as well in the DSS1 ISDN protocol¹³ in addition to the Calling Party Number (3).



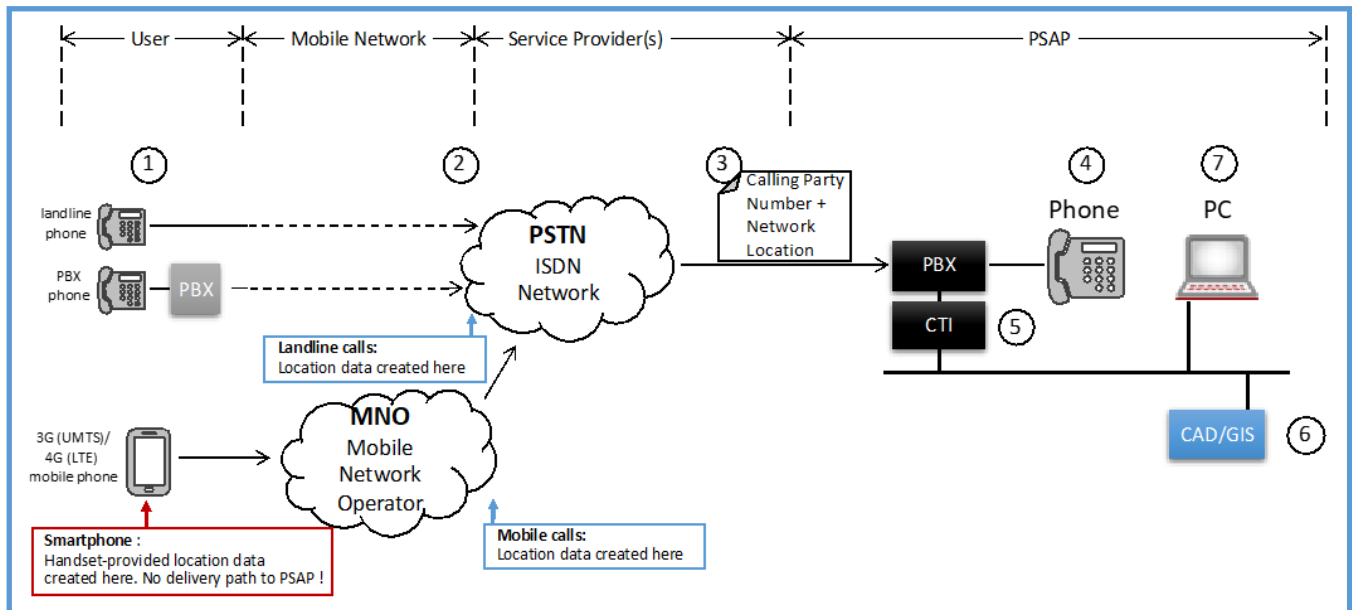
¹²SS7 (Signalling System No. 7) is the ISDN protocol used to interconnect service provider's networks.

¹³DSS1 (Digital Subscriber System No. 1) is the ISDN protocol used to interconnect a service provider's network to a subscriber line, which can be an individual phone line to a single phone or to a PBX system.

There are multiple options of what exactly is transmitted as the location information for mobile originated calls. The range starts with the pure information of the identification number of the cell that picked up the call ("Cell ID"), enhanced by more information to add further precision and narrow down the area of where exactly the caller is. Also, the amount of location information and its precision varies between the different countries, and can even vary between different service providers in one country.

For an overview in more detail, please refer to the EENA paper "Caller Location in Support of Emergency Services."¹⁴

All of this information is declared as "network provided", without leveraging any mobile phone provided information on the location, such as GPS data.



"Handset provided" location information coming from modern Smartphones in principle offers more detailed, granular and precise information, as it's leveraging modern smartphone's enhanced location services. In the world of ISDN networks, handset derived location information cannot be conveyed from the point of origination (the mobile phone), through the Mobile Operator's network, the PSTN, and down to the PSAP receiving the emergency call.

This fact exactly was the motivation to explore additional capabilities, creating "Over-the-top" approaches to deliver handset-provided location information to the PSAP, bypassing the traditional ISDN-based interfaces and leveraging other ways of conveying precise caller location information from the point of origin to the destination in a given environment of existing networks.

The following chapters describe the various methods of transmitting handset location data with currently available mechanisms in order to enhance current systems and network environments, helping to overcome limitations rather short-termed and prior to moving to Next Generation 112 which will solve this challenge in the long term.

EENA released a technical document "Handset Derived Location for Emergency Calls" which in addition to this document can be very beneficial to understand the topic in more detail.¹⁵

¹⁴EENA paper "Caller Location in Support of Emergency Services" http://www.eena.org/uploads/gallery/files/pdf/2014_11_21_EENA_2_2_2_v2%20_FINAL.pdf

¹⁵ EENA technical document "Handset Derived Location for Emergency Calls" http://www.eena.org/download.asp?item_id=98



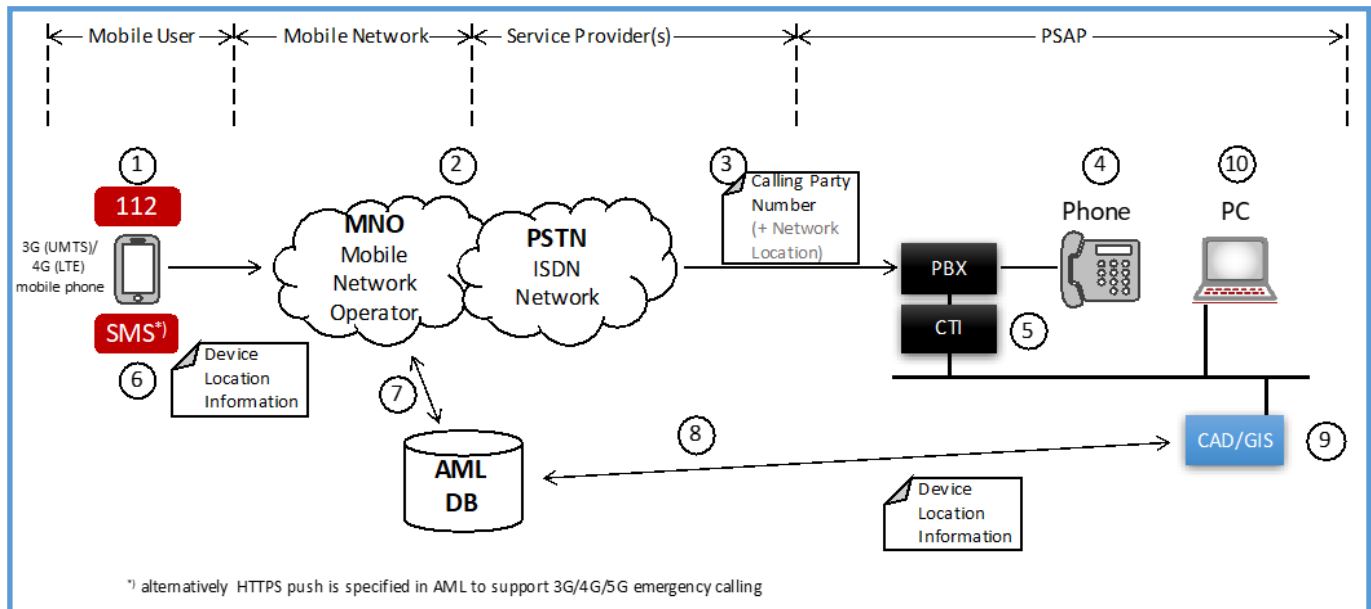
3.3 Over-the-top caller location: AML via SMS and HTTP

Advanced Mobile Location (AML) was one of the first steps towards a formal integration of handset provided location information into the emergency call flow through all networks and the PSAP to answer the call and manage the emergency response.

The AML principle as originally developed by the British Telecom in collaboration with the UK-based Mobile Network Operator "EE" and the handset manufacturer HTC works as follows:

- The emergency call is raised by dialing 112 (in the UK's original case that was 999)
- The Operating System of the smartphone recognises the number as being an emergency number (1)
- In the next step, an SMS message is constructed, placing the latest satellite position (plus additional information) from the smartphone. In case the user has turned off location services, they will be turned on at this step.
- The emergency number is dialed and the call is routed by the network (2) to the appropriate PSAP (3), showing the Calling Party Number as well as potentially the location information provided by the network.
- In parallel, the SMS is sent as a hidden "Provider SMS" (6) to a target SMS center of the Service Provider and is stored in a database (7).
- When the call is answered at the PSAP (4), the CTI integration (5) hands over the Calling Party Number to the CAD/GIS application (9), which in the next step can retrieve the content of the SMS from the database (8).
- Ultimately, the location is presented at the call taker's desktop in the GIS mapping software (10).

AML was adopted as a standard Android Operating System feature by Google in 2016



Due to the continuous development, the appealing simplicity and the resulting success of AML it was finally adopted to become a standard Android Operating System feature by Google in 2016¹⁶, known as "Emergency Location Service (ELS)", mainly supported by EENA's early involvement and continuous education with all stakeholders.

Apple joined the conversation on AML later and released AML as a feature in iOS 11.3 in spring 2018.¹⁷

There are a couple of useful documents available, providing more in-depth information:

- "Advanced Mobile Location in the UK"¹⁸
- "Advanced Mobile Location (AML) – Specifications & Requirements"¹⁹
- "Advanced Mobile Location (AML) – Additional requirements and guidance for Mobile Handset Manufacturers and Mobile Network Operators"²⁰

With the adoption of AML by Google, an additional delivery path for the AML data set was created, allowing a direct data push into a web server of the information through HTTP(S) instead of the delivery over SMS.

AML, its data sets as well as the delivery are well defined in an ETSI standard (ETSI TR 103 393).²¹

¹⁶Google Blog, July 2016 <https://blog.google/topics/google-europe/helping-emergency-services-find-you/>

¹⁷Apple's announcement on AML in iOS 11.3: <https://www.apple.com/newsroom/2018/01/apple-previews-ios-11-3/>

¹⁸EENA document "Advanced Mobile Location in the UK" http://eena.org/download.asp?item_id=95

¹⁹EENA document "Advanced Mobile Location (AML) – Specifications & Requirements" http://eena.org/download.asp?item_id=165

²⁰EENA document "Advanced Mobile Location (AML) – Additional requirements and guidance for Mobile Handset Manufacturers and Mobile Network Operators" http://www.eena.org/download.asp?item_id=227

²¹ETSI TR 103 393 version 1.1.1 (2016-03) http://www.etsi.org/deliver/etsi_tr/103300_103399/103393/01.01.01_60/tr_103393v010101p.pdf

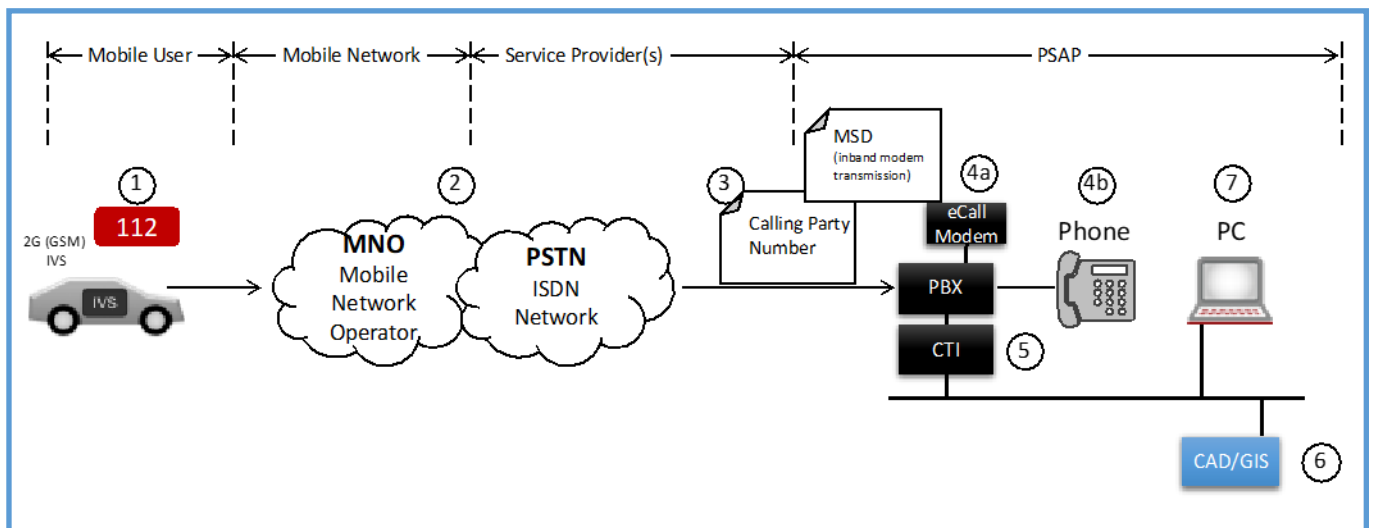
3.4 EU eCall

A very special use case of transmitting caller location information with the incoming emergency call is EU eCall. The In-Vehicle System in the car (which in principle is a 2G mobile phone combined with a satellite positioning receiver) originates a call to 112 (1), which is routed through the Mobile Network into the PSTN (2), and ultimately into the most appropriate PSAP. At the start of this handover process, the Calling Party Number is transmitted, like in any other 112 call as well.

In the first step of the call handling, prior to the call taking process guided by the call taker, the eCall modem in the PSAP is switched into the call, receiving the MSD (Minimum Set of Data), which contains also the geolocation in x/y-coordinates (4a).

After the modem transmission of the MSD has ended, the call is handed over to the call taker to start the call taking process, talking to the passengers in the car (4b).

In parallel, the received MSD is handed over in a CTI process (5) to the CAD/GIS system (6), and made available to look at on a map on the call taker's PC (7).



EU eCall introduces a new method of conveying location data in the voice path of the emergency call. It contains device-provided location data, but is using a transmission method that is somewhat close to the delivery of network-provided mobile phone data as discussed in the previous chapter. Instead of using the ISDN D-Channel as a signalling channel for the data transmission, it does make use of the ISDN B-Channel that is used for the payload.

The transmission of location data in Third Party Services (TPS) eCall, the private industry version of EU eCall, shall not be discussed here, as this is very much depending on the mechanisms used by different car manufacturers and their respective service centres or authorised assistance organisations. In general, EN16102 as a standard for TPS eCall integration into PSAPs does offer multiple methods of data transmission.

3.5 Over-the-top caller location: Smartphone App

A very popular approach to transmit Smartphone-provided location data is to introduce smartphone apps to communicate to the PSAP in the context of 112 calls.

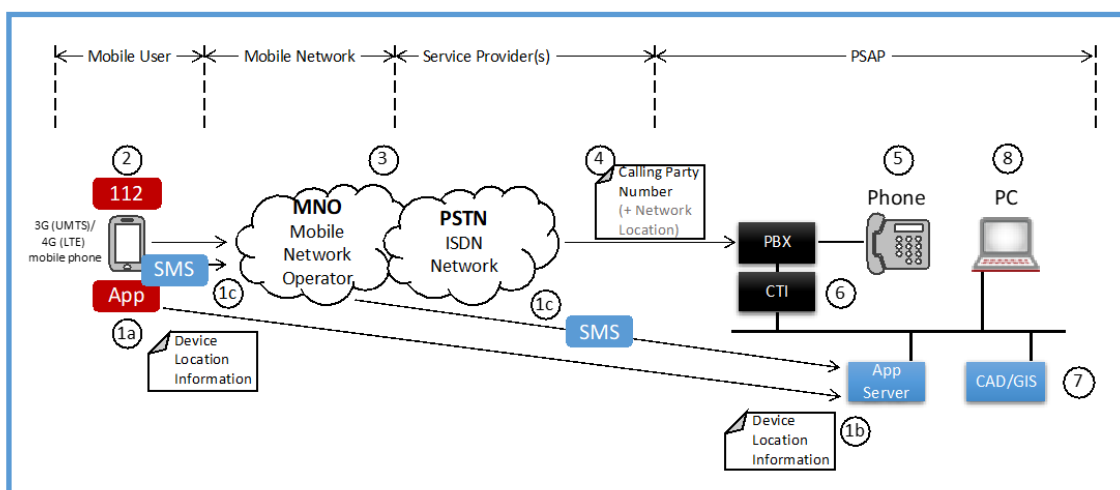
The use and the specific implementation of smartphone apps can differ in many ways, in terms of user interfaces, as well as in terms of implementation in the backend of the app, managing the different types of data that the app provides, but in general the majority of apps are using the same kind of principles to connect the caller to the PSAP.

Instead of dialing 112, the caller pushes a button on the smartphone app (1a). This typically triggers a process prior to originating the call to 112, sending the location data over a mobile internet connection to an application server in the PSAP (1b).

In case there should be no mobile internet service through 3G/4G networks available at the location of the caller, some smartphone apps have included a mechanism to create an SMS message (1c) containing the location data, and sending this SMS message to a specific number as part of the traditional 2G mobile service. In fact, the SMS would be received and processed by the application server again.

After (or even in parallel with) the data transmission, the app dials 112 (2), and then the call is handled as a normal 112 call by the mobile network and the PSTN (3), is handed over to the most appropriate PSAP (4), and is answered by the call taker.

Through CTI integration (6) the Calling Party Number of the caller's smartphone is passed to the application server, which now can match this Calling Party Number to the location data it just received, and hand the location information over to the CAD/GIS system (7) to be displayed on the call taker's PC (8).



3.6 Over-the-top caller location: HTML5 Geolocation

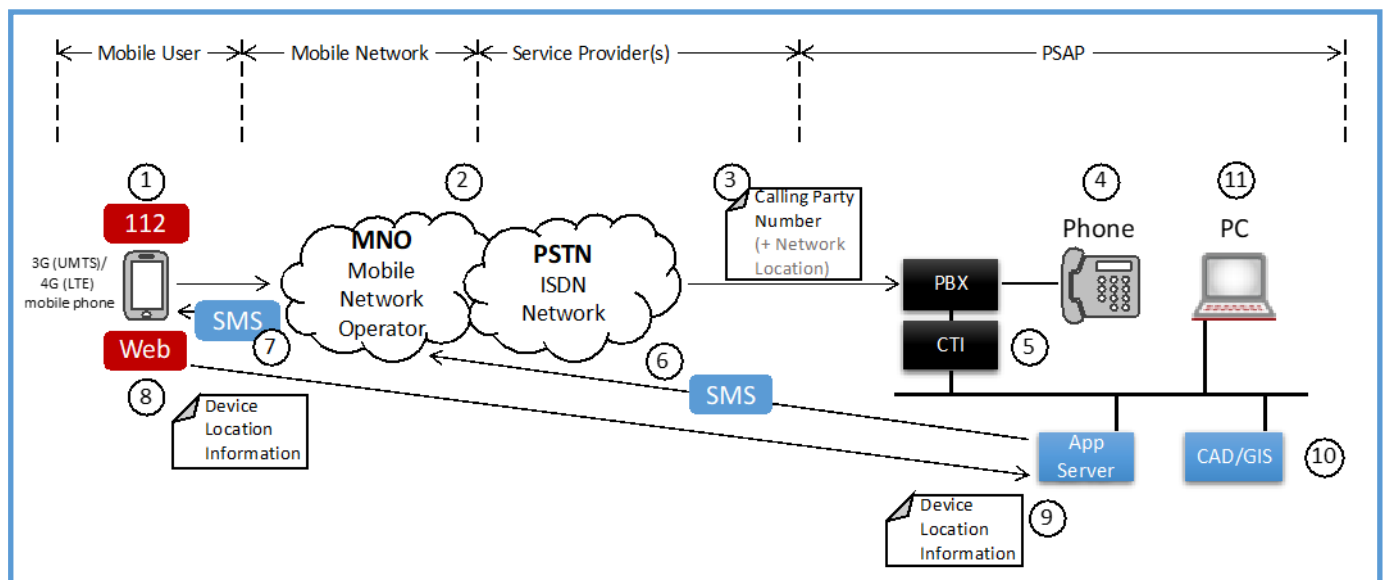
Another method of "Over-the-top" delivery of caller location information can be achieved by embedding internet applications into the call PSAP processes. Version 5 of the web application programming language HTML (HyperText Markup Language) offers a very convenient way to request location information from devices through a browser.²²

HTML5 Geolocation is involved after the initial delivery of the call to the PSAP. The process is started either automatically or manually from the PSAP's CAD/GIS applications, leveraging a location service that is driving the process and sequence of events necessary to perform HTML5 geolocation in an Application Server, comparable to the App Server in the previous chapter:

- The call taker receives the emergency call on his phone and in the CAD/GIS application (3, 4 and 5)
- He then invokes a process through an Application Server. Probably from within the

GIS/CAD application, or through a separated (Web-)Application, the call taker triggers an SMS to be sent out to the caller.

- Receiving the SMS on his smartphone, the caller will be asked to click on the link embedded into the SMS (7). Most probably, the caller will be asked by the browser to agree on sharing the location information, which can be seen as an additional element to adequate data privacy.
- This action is going to open a browser window on the smartphone. The browser is executing the web application's HTML5 code provided as a sub-function of the Location Information Service (8), requesting the location information from the smartphone's Geolocation API (Application Programming Interface).
- In return, the location data is sent to the Application Server (9), which then forwards the information to the CAD/GIS (10) application server, and from there back to the call taker's desktop CAD/GIS application (11).



More information and the finer details of HTML5 Geolocation can be found in the document "HTML5 Geolocation" created by EENA.²³

²²Can be tested by browsers: <https://html5demos.com/geo/>

²³EENA document "HTML5 Geolocation" http://www.eena.org/download.asp?item_id=237

3.7 Concept: PSAP Location Information Service

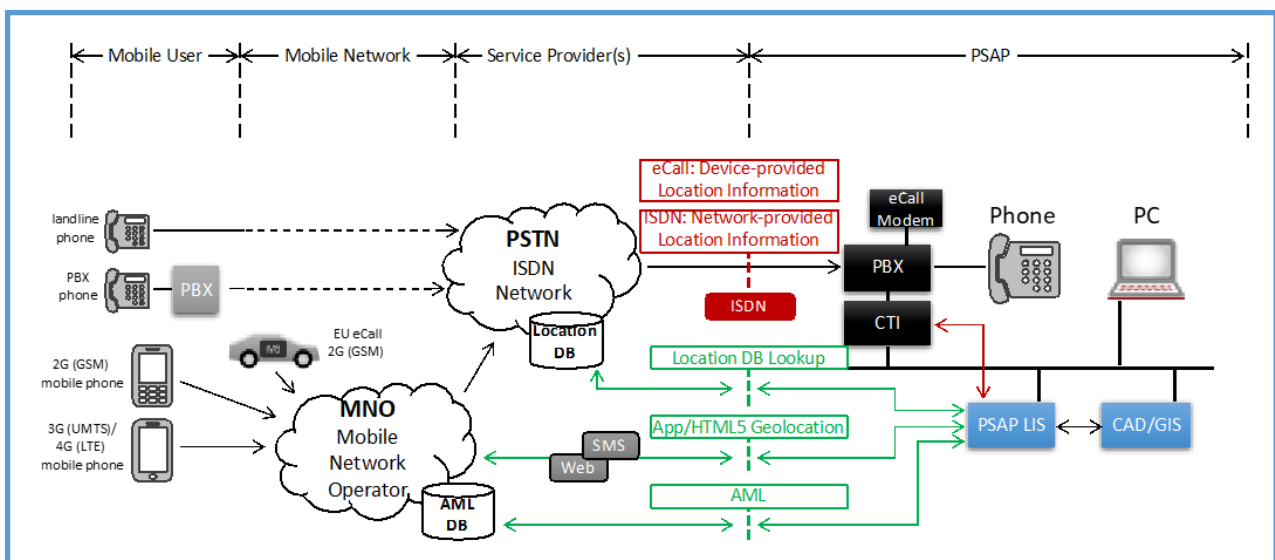
The PSAP Location Information Service (PSAP LIS) is introduced here in preparation for a wider set of location-related services that will be used in Next Generation 112 scenarios.

As discussed in the previous paragraphs, technical services' evolution led to a couple of currently relevant and operationally used location services:

- Network-provided location information conveyed into the PSAP through the ISDN access line in the D-Channel
- Database-lookup based on network-provided call information available from the emergency call signalling in the ISDN D-Channel
- Device-provided location information leveraging different methods of transmission
 - ◊ Advanced Mobile Location with SMS
 - ◊ Advanced Mobile Location with HTTP(s) data over the (mobile) internet
 - ◊ EU eCall with in-band transmission in the ISDN B-Channel (modem in voice path)
 - ◊ HTML5 Geolocation with SMS and HTTP(s) data over the (mobile) internet combined

PSAP Location Information Service is introduced here in preparation for a wider set of location-related services...

The following graphic tries to give a summary of the different services and mechanics currently in use.



PSAP Location Information Service may solve some challenges...

With the complexity and the expected continuation of new or amended location services to appear in the future, PSAPs might be challenged in really introducing all of these services into their operational CAD and GIS systems and keeping up with the technical development.

As we currently observe this in the market, only very few PSAPs can afford to pick up all of the services and integrate them into their applications because of various factors:

- The current PBX, CAD and GIS systems' software is not capable of connecting to the new services' interfaces. Complete replacement of the current software with a more open and modern web-based application would be the most appropriate option to include new services, but the current software has not yet reached the end of its life cycle.
- The current software could be expanded to include new services, but creating multiple different new interfaces would require a high effort in project time and costs, whereas a single new web services interface could be a viable option to establish as part of a new project.

In order to become more independent from the operational surrounding of CAD, GIS and PBX, a concept of a "PSAP Location Information Service (PSAP LIS)" may become very appropriate in order solve a couple of challenges:

- Consolidating multiple different location services
- Taking care of the different types of integrations and required workflows
- Harmonising the data transmission format towards the GIS and CAD systems

With that kind of approach, the operational environment managing communications and processes will become more independent and less influenced by forthcoming technological development, as the central point to add new location capabilities can be the PSAP LIS.



3.8 Limitations in current environments

Summarising the different elements of caller location technically available to emergency services, this is the picture:

- There is no standard or native way available to emergency calls in the current still ISDN-centric world of voice communications that does deliver precise handset provided caller location information to the PSAP without any additional activities beyond dialing 112 on the phone and accepting the call in the PSAP.
- The current standard delivery of network provided location information, if available at all, is not precise (Cell ID or Antenna Sector) to call takers' or dispatchers' needs, allowing to send responders to a "dispatchable address".
- Multiple over-the top approaches are available, co-existing side by side, not covering all of the major smartphone operating systems on the market.²⁴
- Over-the-top location solutions are not integrated by default into CAD/GIS applications.
- Availability in 2018 very often still depends on regional or individual PSAP initiatives.

The emergency response delivered to citizens is not homogenous regarding technology supporting precise location services, and is – depending on the structure of PSAP organisations – differing from country to country, region to region, city to city, PSAP to PSAP.

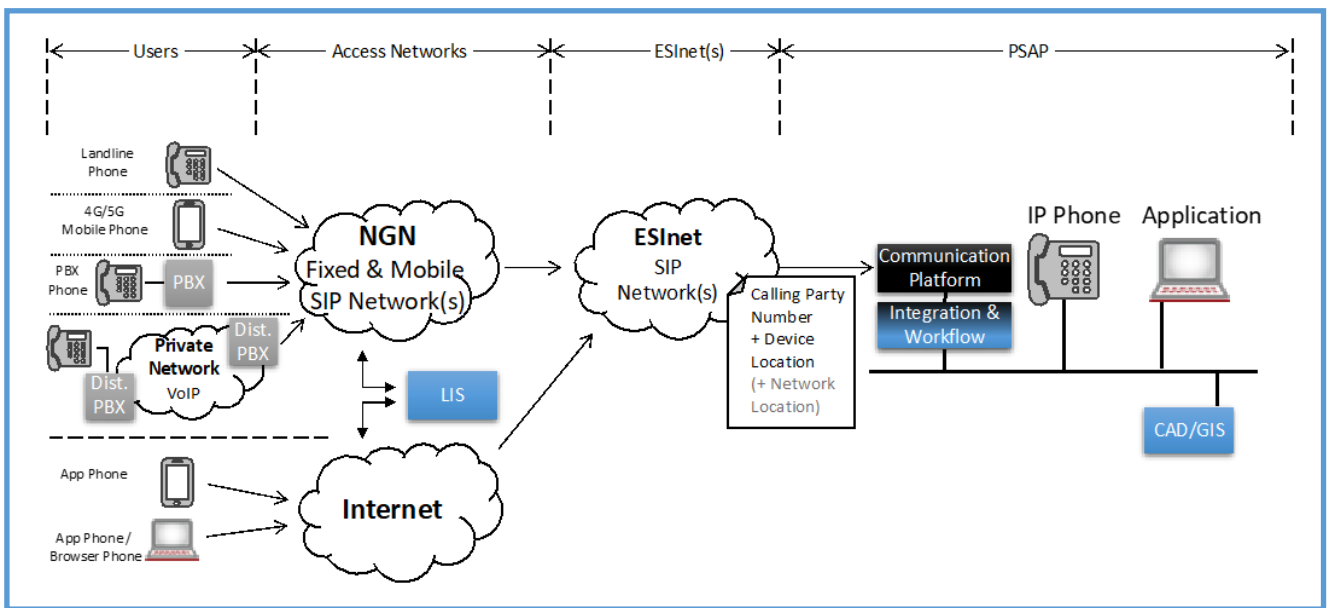
²⁴Major smartphone operating systems considered: Google Android, Apple iOS, Microsoft Windows Mobile

The ESInet as a construct is a private, managed, and routed IP network...

4. GIS and Next Generation 112—Information and Architectures

Besides adding the capabilities to use other media than just voice in an environment building on Next Generation 112 (NG112), the fundamental differentiator is going to be the immediate availability of geolocation information at the time of the call ringing at the PSAP call taker's phone.

The following graphic shows an end-to-end scenario in NG112:



Compared to the architectures in current deployments based on PSTN and ISDN, the major change is in the introduction of the ESInet.

The ESInet as a construct is a private, managed, and routed IP network. It serves a set of PSAPs, a region, a state, or even a set of states. An ESInet can be interconnected to neighbouring ESInets. ESInets are functions typically provided by Service Providers.

The location information is conveyed to the PSAP as part of the information embedded into the incoming call's signalling...

In order to illustrate the value of NG112 in terms of dealing with embedded location information, we have to assume that location information can be consistently transmitted along the full 112 chain

- from the originating user device: individual landline phones, mobile phones, phones attached to a PBX or private networks or applications on smart devices or PCs
- through the access networks: SIP-based Next Generation Networks of service providers (fixed, mobile), or the Internet
- through the ESInet(s) for emergency call routing purposes
- into the PSAP for emergency call handling, ultimately resulting into appropriate emergency response

The above graphic excludes views to connect current PSTN/ISDN based implementations of 112 only for the purpose of keeping the picture as simple and clear as possible due to the focus of this document. Of course we would assume connectivity as a given in a migration scenario which might cover a period of multiple years.

In that architecture, location information is provided either at the time of the call origination by the device that is used to make the call, or is added in the next step by the fixed or mobile access networks as well as the Internet with the support of Location Information Services (LIS).

The location information is conveyed to the PSAP as part of the information embedded into the incoming call's signalling.

The following sections are going to describe in more detail the flow and use of location information and GIS.

More detailed and advanced information on NG112 architectures can be found in EENA's NG112 Long Term Definition (LTD) document.²⁵

²⁵EENA Next Generation 112 LTD: http://www.eena.org/uploads/gallery/files/pdf/2013-03-15-eena_ng_longtermdefinitionupdated.pdf

4.1 Location Information embedded into Call Signalling information

Location information is a crucial aspect for the NG112 and the ESNET in two ways.

1. First, ESNET makes decisions about the call routing and uses location information for that purpose.
2. Second, precise location information is also needed to dispatch first responders.

The protocol used to establish Voice over IP-calls in an NG112 environment is called Session Initiation Protocol (SIP), and SIP has the capability to carry location information alongside the call.

SIP-based emergency calls in NG112 pass location information in a "Geolocation Header,"²⁶ either as embedded information "by value" (similar to a document attached to an email) or as a pointer to location information in external systems "by reference" (like a link to a document in an email) plus a "Service URN" (referring to the requested service) to an Emergency Services Routing Proxy (ESRP) to support routing of emergency calls based on that location information.

"Location by value" uses the so-called PIDF-LO²⁷ container, which typically contains a data structure describing a civic address, but could be used for Geo-coordinates (x/y/z) as well. The PIDF-LO is a static element which does not change during the process of the emergency call.

"Location by reference" uses a "Location URI", which basically is a link to an external source, "representing" the location information, but "being" the location information. Using location by reference does allow for dynamic location updates, which is very useful if the caller or the object that raises the emergency call itself is moving (e.g. in a car, on a train).

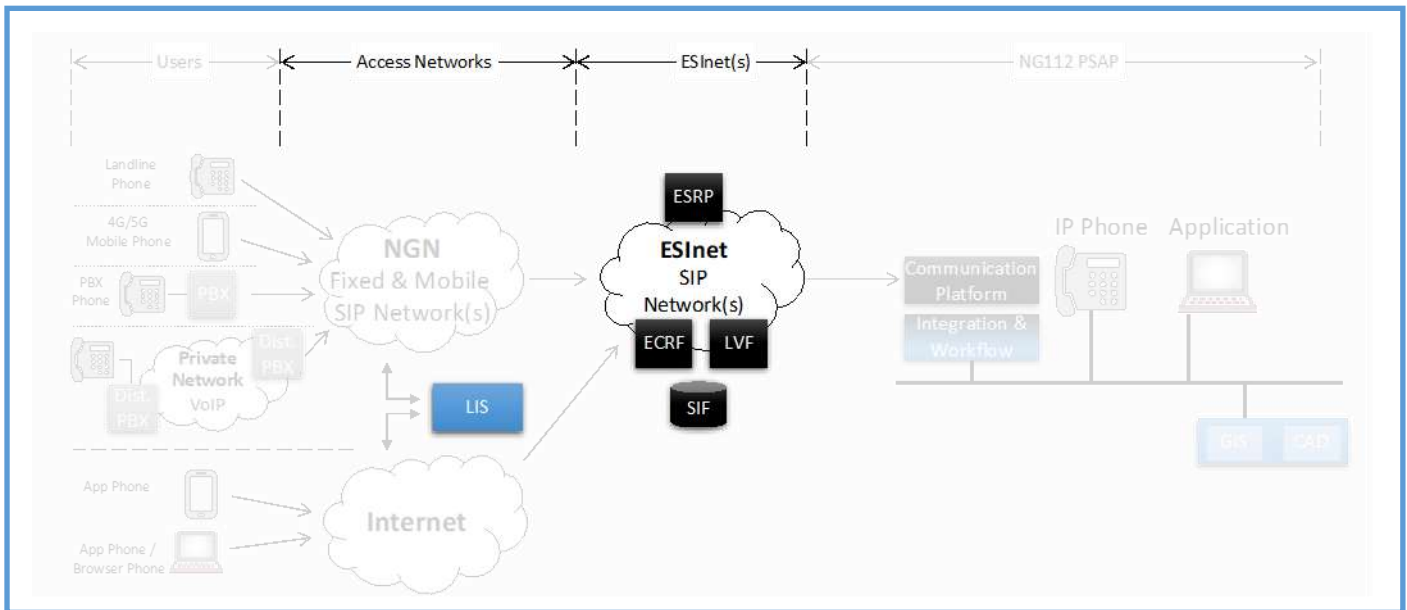
More extensive information on SIP end-to-end emergency call mechanics can be found in the EENA "Next Generation 112 Long Term Definition" document.

²⁶Geolocation Header as specified in IETF RFC 6442

²⁷PIDF-LO: "Presence Information Data Format - Location Object", as described in IETF RFC4119, updated by RFC5139 and RFC5491

4.2 ESInet functional Elements

There are a number of functional elements in the ESInet or associated to the ESInet that should be briefly explained to better understand GIS in NG112, as illustrated in the following graphic:



The ESRP uses the Emergency Call Routing Function to choose the next hop when processing a call...

4.2.1 ESRP (Emergency Services Routing Proxy)

The Emergency Service Routing Proxy (ESRP) is a SIP-based call routing engine inside the ESInet. In essence, it can be compared to the Local Exchange switch in a classic PSTN or a PBX in an private enterprise network.

The ESRP uses the ECRF (Emergency Call Routing Function) to choose the next hop when processing an emergency call. It does apply route policies as well to determine the next hop. The route policy may take into account the traffic or availability state of a PSAP, time of day, and other criteria.

The ESRP is the entity in the ESInet that extracts the Geolocation Header from the SIP invite message in order to work with it on determining the emergency call routing.

4.2.2 ECRF (Emergency Call Routing Function)

The Emergency Call Routing Function (ECRF) is the routing database used for all calls that need to be handled by the ESRP. It is queried from the ESRP using the IETF LoST (Location to Service Translation) protocol, receiving the geolocation plus a "Service urn" and return a URI of where to send the call out to.

It provides the capability to determine a civic address or a point in a polygon, defining the location of the callers in a specific area, in order to determine which PSAP this area is associated to.

Besides the geolocation-based routing capabilities, the ECRF also decides which is the correct service (police, fire, ems, poison control) to route the call to based on the incoming service URN (comparable to today's emergency numbers).

The ECRF also decides which is the service to route the call to...

4.2.3 LIS (Location Information Service)

The LIS is an external function to the ESRP, being predominantly part of the Access Network's functional elements.

The LIS provides a couple of useful functions:

- A de-reference function for location by reference, using the HELD (HTTP-Enabled Location Delivery)²⁸ protocol: given a location URI, the LIS returns the location value as a PIDF-LO.²⁹ In particular, applications can choose to dereference a location URI at any time, possibly several times.
- A validation function which uses the LVF for civic addresses.

In NG112, the LIS also supplies location (by value or reference) to the endpoint that originates the emergency call, or to proxy operating on behalf of the endpoint. With that function (which is not in the focus for GIS in the PSAP for this document) the resulting PIDF-LO or location URI must appear in the initial SIP message in a Geolocation header, so this basically is a mandatory pre-requisite for the NG112 emergency call chain to work.

²⁸HELD: "HTTP-Enabled Location Delivery", as defined in IETF RFC 5986

²⁹PIDF-LO: "Presence Information Data Format - Location Object", as described in IETF RFC4119, updated by RFC5139 and RFC5491

Key function of the LVF: ensure a “valid” location for the call as a “dispatchable address”

4.2.4 LVF (Location Validation Function)

Location information when provided in civic address form must be checked for correctness, making sure that e.g. a street name really exists in a specific city, that there are no spelling mistakes, and the street numbers are available on that specific street.

A civic address in short must be proved sufficient for routing and dispatching purposes prior to the call being placed. So the key function of the LVF is to make sure there is a “valid” location for the call as a “dispatchable address”.

4.2.5 SIF (Spatial Information Function)

The Spatial Information Function (SIF) is considered the base for databases in NG112. It is a specialised form of a Geographic Information System, which may be implemented on a conventional GIS with the appropriate interfaces.

The SIF supplies data for the ECRF and the LVF to operate on. Beyond that, it provides map views for alternate PSAPs that might not happen to have the map data to manage calls that they receive as an overload target from another PSAP.

Operating a SIF in the ESInet requires a standardised method of replicating layers from the master SIF to the external databases in the PSAPs. When calls are answered at an alternate PSAP, map views are generated from off-site replicas of layers in the SIF system, which are maintained by the SIF's GIS interface.

Beyond the mapping services, the SIF also provides Geocode Services, which allows a PIDF-LO with Civic Address to be converted into (a PIDF-LO with) geo position data and vice versa.



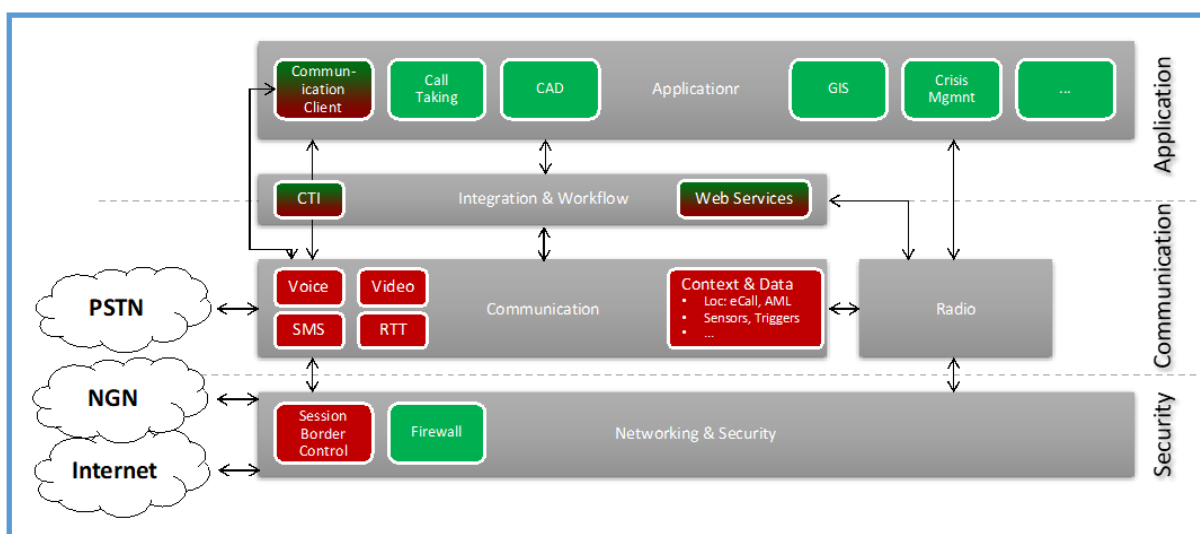
4.3 PSAP Architecture Layers – Where is the change going to happen?

In order to better understand the difference between 112 and NG112, it is worth having a look at architectural developments.

Whereas in current Public Safety Answering Points there typically is a setup mainly consisting of an Integrated Command and Control System (ICCS) which combines both operational applications as well as voice communications into a single system, consisting of hardware and software, there is a clear industry move to software-only architectures. As more and more specific hardware becomes obsolete the more real-time communications move from analog and digital (ISDN) to IP-based communications.

Of course, it needs a hardware infrastructure to be deployed on, but in times of virtualisation this hardware is becoming more and more generic with an abstraction layer in the space of virtual machines and data centres.

So moving towards a pure software solution, there is a second trend crystallising: a separation into a communications layer (mainly red boxes) and an applications layer (mainly green boxes), glued together using standard web interfaces in an Integrations and Workflow middleware layer, based on and supported by a networking and security layer, as shown in the graphic below:



4.3.1 Application Layer and Communication Layer

The application layer holds the well known operational tools for Call Taking, GIS, CAD, Crisis Management, Analytics and others, as well as communication tools being partly linked directly into the communications layer.

The communications layer is taking care of all real-time and near-real-time media streams, voice, video, and text-based communications (SMS, Real Time Text), and it includes gateway functions for classical voice communications over the PSTN with ISDN and analog interfaces.

It also picks up IP-based media streams from Next Generation Networks as well as the Internet, that have passed through the networking and security layer.

As more and more new services will be based on IP communications, there will also be more context and additional data to be delivered through these communications, which requires more extensive capabilities to treat, manage, add or change this context in the communication layer, but even more important in the workflow and integration middleware between communication and application layer.

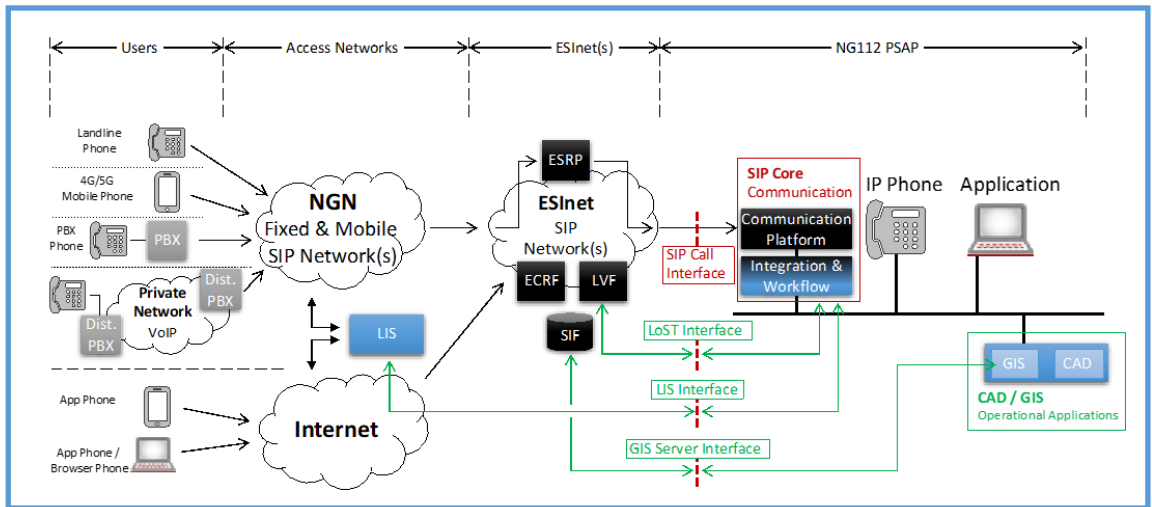
The communication layer is what in previous times was called the PBX dedicated to voice communications.

The most prominent "context data" is obviously the location information that is used in GIS applications and therefore is a focal point of this document. Other context is all additional data associated with e.g. eCall (MSD data), AML, or emergency apps.

The application layer is working with the contextual data to support call takers in supporting the emergency case with insightful situation data, driving meaningful and efficient decision making.

4.3.2 SIP Signalling in the Communication Layer

With this architecture in mind, let's return to the end-to-end scenario in NG112 shown previously, focusing on the interfaces and capabilities associated with those interfaces:



The SIP Call interface is not limited to voice communication only...

4.3.3 SIP Interface for Real Time Media

The key interface between the NG112 PSAP and the ESInet is the SIP Call Interface. Whilst it is named "call"-interface, it is not limited to voice communication only. In principle, SIP (Session Initiation Protocol) allows voice, video and text communication, standalone in separate session or combined in one session as "Total Conversation", and in different flavours (e.g. text communication as Real Time Text RTT or as Instant Messaging).

More detailed information on Voice over IP (VoIP) and SIP can be found in the EENA paper "The fundamentals of Voice over IP" (http://www.eena.org/download.asp?item_id=232).

One of the key capabilities of SIP as a protocol is to carry additional context to the associated media streams, and especially in focus of this document location information, as described earlier.

4.3.4 Application Interfaces to exchange data

Compared to current 112 PSAP architectures, there are additional Application Interfaces specified for an NG112 PSAP. In most traditional 112 PSAPs, the only interface to the outside world is the ISDN trunk connecting the call takers to the callers through the PSTN.

Only in recent years have PSAPs started to connect their staff to the IP-based services of the internet, very often on isolated PCs in order to protect the core installed base of the Integrated Command and Control System. These PCs typically were used to give access to information and search services like e.g. Google and Bing, or to look up case-relevant context in social media platforms like e.g. Twitter and Facebook.

In the architecture of NG112 PSAPs, access to information leveraging the IP-technology is built in by definition through a couple of well-defined interfaces.

The description of the three main interfaces to follow illustrate how the location information of the Geolocation Header handed over by the SIP Invite message at the PSAP's Communication Layer is handed over and shared with the Application Layer.

4.3.4.1 LoST Interface

The LoST (Location to Service Translation) Interface used for two purposes:

- **Call Routing inside the ESInet**

The ESRP (Emergency Services Routing Proxy) as the "telephone switch" inside the ESInet does leverage the LoST interface to query the ECRF (Emergency Call Routing Function) where to send the call to as the next hop (e.g. the terminating PSAP to take the call or another neighbouring ESInet). For this routing request, it does use the PIDL-LO inside the Geolocation Header in the call setup request (SIP Invite), hands it over to the ECRF and does receive the targeted next hop in return, in order to process the call.

- **Location Validation by the LVF**

The Location Validation Function (LVF) is invoked for every call origination end device prior to any potential use for emergency call routing, which means that every emergency call needs to have a valid location attached before a call taker can answer the call.

The LoST interface can only use Location by Value.

4.3.4.2 LIS Interface

The Location Information Service (LIS) Interface is used in cases where the PSAP receives a Geolocation Header with Location URI, so location information "by reference". In this case the PSAP uses the Location Information Service in order to de-reference this link and to obtain the current true location value.

4.3.4.3 GIS Interface

The GIS Interface is used by PSAP applications to communicate with a Spatial Information Function (SIF) in the ESIInet. The SIF is very useful when the PSAP is not the primary PSAP to answer an emergency call from a specific region, but rather is an alternative PSAP for that region in case of traffic overflow or service shutdown at the primary PSAP. In that case the alternate PSAP can request geographic information in the context of the call (e.g. more details about the surroundings of the location information delivered in the SIP invite message) or even receive maps from that location that they don't have in their own GIS.

4.3.5 Concept: PSAP Location Information Server (PSAP LIS) in NG112

As described above, one of the big benefits to introduce NG112 is to make location information available as a core concept in emergency calling. In order to achieve this, a number of new interfaces to exchange data with functions in- and outside of the ESIInet is going to be introduced.

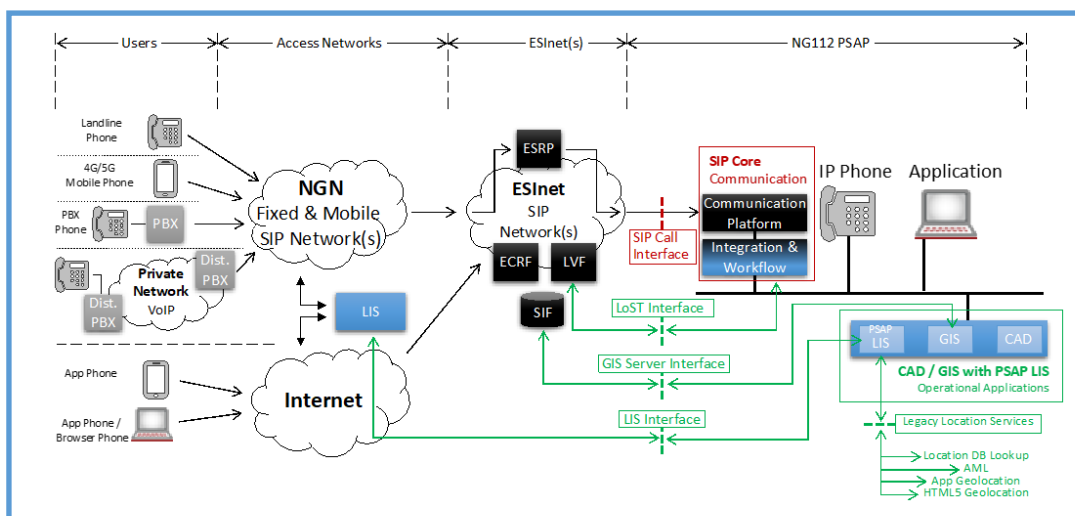
One of the interfaces, the LIS interface, is used to allow communication to the Location Information Service outside of the ESIInet, in order to de-reference location received by reference from the SIP Invite message with the emergency call.

At this point, it might be appropriate, to review the concept of the PSAP LIS introduced previously and reflect its position in NG112.

The concept of PSAP LIS has been introduced as an element to consolidate location information requirements and queries in current non-NG112 PSAPs, allowing them to more easily add location services to their operational environment than potentially possible in an approach of individually integrating multiple different services in to the existing GIS and CAD platforms.

In this case, we could assume that the PSAP LIS exists already at the time of transition from "Current 112" to "NG112", which naturally would result in

- a. Having the Legacy Location Services still available during or even after the transition to NG112
- b. Adding the communication capabilities to the NG112 LIS as an additional function to the PSAP LIS



This approach can help to focus the efforts of transitioning to NG112 to the communication layer (this is where the larger changes are going to occur), and reduce its influence to the operational CAD and GIS applications to a minimum.

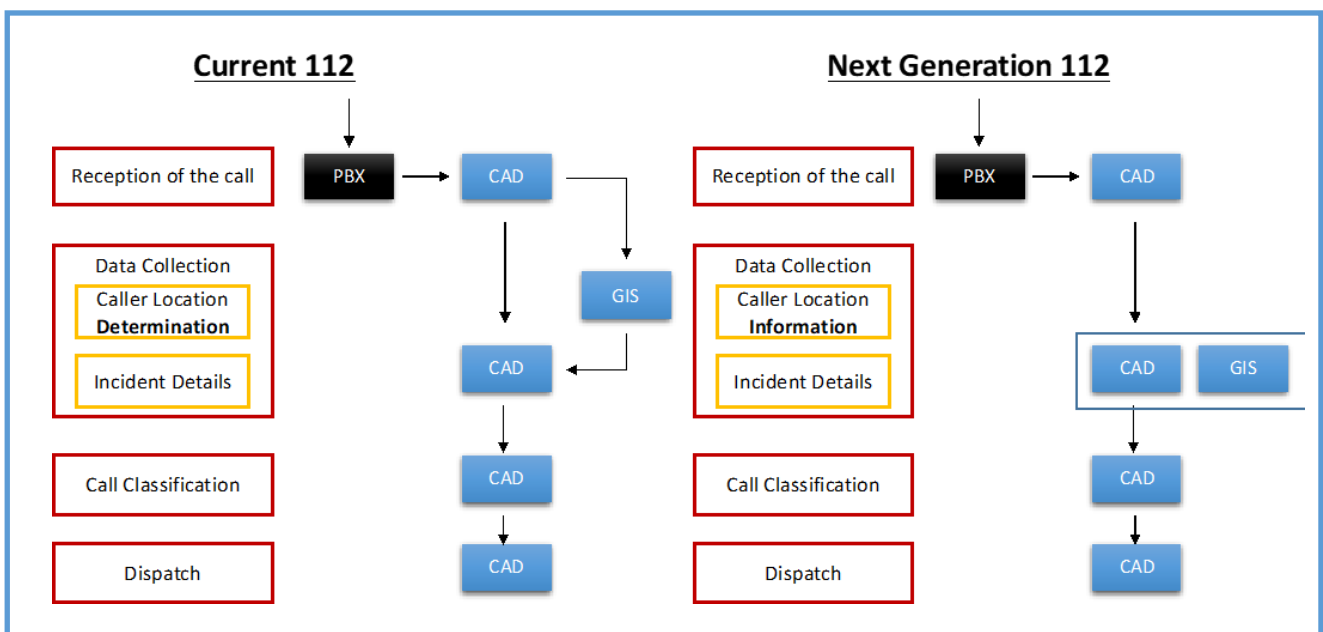


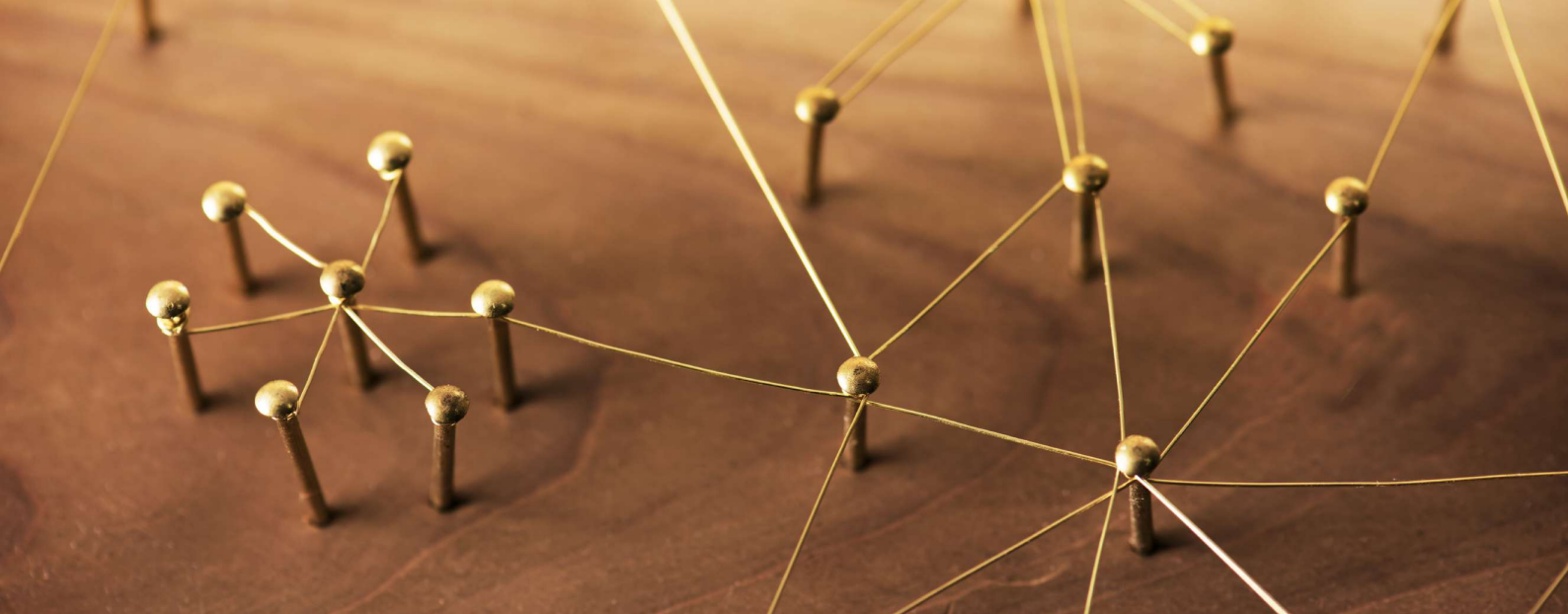
5. GIS and Next Generation 112: Considerations on Process Influence

Understanding how GIS is embedded into the 112 chain in current environments as well as in a future NG112 environment, we now can return to a more process-centric viewpoint and conversation.

Compared to the description of parallel tasks for the call taker on both GIS and CAD sub-systems in current 112 implementations, the key change in NG112 will be in the more assured availability of location information with the incoming call:

Whereas in current 112 during "Data Collection" the determination of the caller location is a task that requires attention, sometimes a lot of dedication and time, using both tools, the CAD and GIS, we see that in Next Generation 112 this is likely to change. Based on the availability of location information from the start of the call onwards, the task of *determining* the caller's location changes to *checking* the caller's location during "Data Collection". This can be a considerable gain in effort and time, which can speed up the response process.

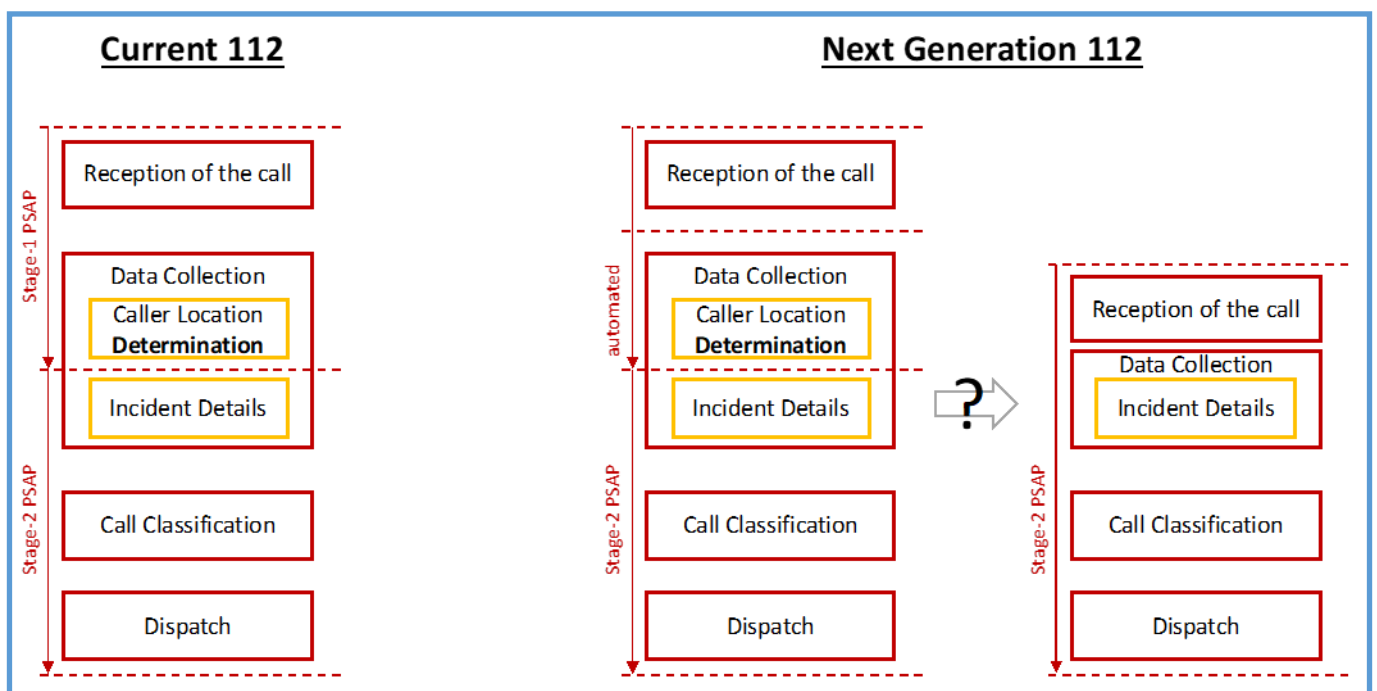




Also, as a side effect, the actual work with tools can be more focused on the CAD application, as the availability of location information is going to be a given from the start of the process.

Another thought to follow in the future is to think about a potential enhancement of the overall process, especially in a 2-stage PSAP model. Whenever an operational model currently follows a 2-stage approach, with stage 1 basically determining the caller's exact location and asking "Which service do you need?", this can potentially be automated in NG112, assuming that the location information provided is precise enough, or close to a "dispatchable and valid" address.

Beyond the positive effect of shortening the process, in essence this could open the question if stage 1 PSAPs could be completely abolished.



GIS will play a more advanced role as the presentation layer for different location-based information...

6. Summary and Conclusions

The move from "Current 112" to "NG112" will come with a couple of changes, driven by the use of technology, and reaching into business processes as an element of "Digital Transformation", of progress and innovation based on a higher amount of automation.

Technical architectures and implementation will become cleaner according to their tasks of "communication" and "procedural operations", and GIS will play a more advanced role as the presentation layer for different location-based information.

Any of the ideas and thoughts mentioned in the area of "process influence" have still to be reality-checked and a lot of the potential outcome from a tighter integration of location information into the NG emergency calls, and probably an altered use of Geographic Information Systems in NG112 environments are highly dependent on the individual operation model in a country or area.