Caller location in NG112

End-to-end approach

This document explores the multiple scenarios using different end user devices and the corresponding location options, throughout the NG112 architecture.

eena

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CALLER LOCATION IN NG112 – END-TO-END APPROACH

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EXECUTIVE SUMMARY

Location is an essential aspect of efficient and effective emergency services. Location, more precisely the determined locations, are used first during the emergency communication flow to identify the most appropriate Public Safety Answering Point (PSAP) and later to provide and dispatch units to where the help is needed.

The NG112 architecture provides a blueprint for modern, highly effective and interoperable emergency services. Its technical specification standardises the way location information is transported, the way it is formatted and how it can be retrieved during the emergency communication.

This document aims to provide an overview of multiple scenarios using different end user devices and the corresponding location options.

1. LOCATION OVERVIEW

Locations can be expressed in multiple ways and are used differently throughout an emergency communication. Additionally, when considering emergency situations, there are even multiple different locations (e.g. the location of the person initiating the emergency communication, the location of the event/situation, the location where help is actually needed).

This paper will focus on the location of the person initiating the emergency communication.

1.1 Location Purposes

Locations serve multiple purposes in an emergency situation. They can be used for ***Routing*** and for ***Dispatch***.

When people initiate an emergency communication, they are looking for help. At first, their location is used to identify which services, people and/or organisations can assist them in their situation. In this context, the location is used to route the emergency communication to the most appropriate endpoint. The location is used for ***Routing*** purposes.

Once the emergency communication is established, assistance is sent to the location where help is needed. The location is used for ***Dispatch*** purposes.

1.2 Location Formats

Currently, there are two standardised formats for expressing locations in Next Generation 112: ***Civic,*** which expresses a location in the form of an address, and ***Geodetic,*** which expresses it in the form of a geographical shape (e.g. Circle, Point, Ellipse, etc.).

Civic Example (XML namespaces are not shown in this example):

```
<civicAddress xml:lang="en">
        <country>BE</country>
        <A1>Brussels</A1>
        <A2>Brussels</A2>
        <RD>Avenue de la Toison d’Or</RD>
        <HNO>79</HNO>
</civicAddress>
```

Geodetic Example (XML namespaces are not shown in this example):

```
<Point srsName="urn:ogc:def:crs:EPSG::4326">
        <pos>50.83396 4.35206</pos>
</Point>
```

1.2.1 Presence Information Data Format Location Object (PIDF-LO)

NG112 embeds location information using the standardised Presence Information Data Format Location Object (RFC 5491), as shown in the examples below using the civic and geodetic example data.

PIDF-LO Civic Example (XML namespaces are not shown in this example):

```
<presence entity="pres:ggjv4gjwh6zq05gn0">
   <tuple id="ggr17c3v6z8zsobfn">
     <status>
        <geopriv>
         <location-info>
            <civicAddress xml:lang="en">
              <country>BE</country>
              <A1>Brussels</A1>
              <A2>Brussels</A2>
              <RD>Avenue de la Toison d'Or</RD>
              <HNO>79</HNO>
            </civicAddress>
          </location-info>
         <usage-rules/>
         <method>Wiremap</method>
       </geopriv>
     </status>
     <timestamp>2021-02-12T19:00:55.536612+00:00</timestamp>
   </tuple>
 </presence>
```

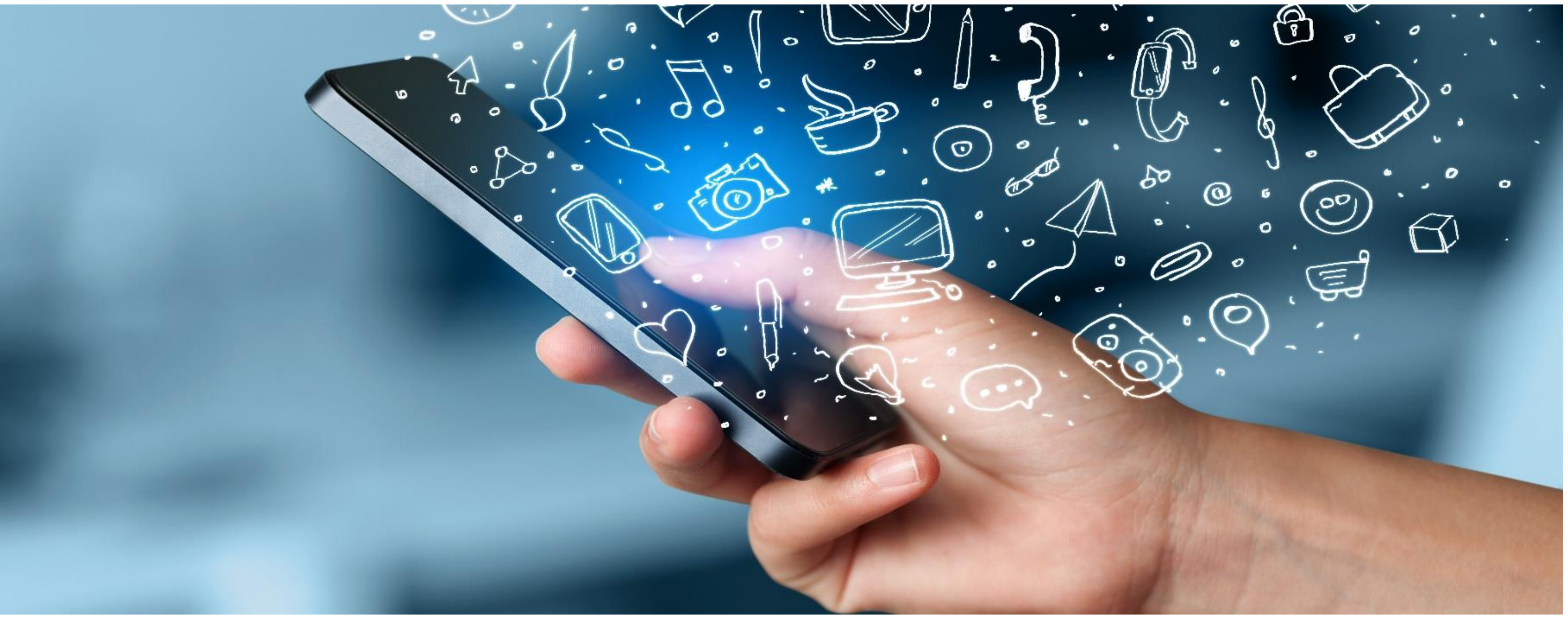
PIDF-LO Geodetic Example (XML namespaces are not shown in this example):

```
<presence entity="pres:ggjv4gjwh6zq05gn0">
   <tuple id="ggr17c3v6z8zsobfn">
     <status>
       <geopriv>
         <location-info>
            <Point srsName="urn:ogc:def:crs:EPSG::4326">
               <pos>50.83396 4.35206</pos>
            </Point>
         </location-info>
         <usage-rules/>
         <method>GPS</method>
       </geopriv>
     </status>
     <timestamp>2021-02-12T19:00:55.536612+00:00</timestamp>
   </tuple>
</presence>
```

1.3 Location Transport

Next Generation Emergency Services are technically based on the Session Initiation Protocol (SIP). The protocol allows different kinds of media sessions to be arranged (e.g. voice, video and/or text), allows additional data to be transported, and provides a subscribe/notify mechanism.

Location information can be transported either by reference, referred to by SIP header(s) or by value as part of the SIP body.



1.3.1 Location by Reference

Location by Reference is transported via a Geolocation header. The term "by Reference" simply means that the actual location is not transmitted, but a pointer towards it instead. This pointer can then be resolved to retrieve the actual location.

The value of the Geolocation header determines the protocol that must be used in order to resolve the pointer, usually SIP or HTTPs.

Example:

```
Geolocation: <sips:+43123456789@mobile.network.provider.com>

Geolocation: <https://mobile.network.provider.com/d3e042aa9b738add9>
```

A SIP reference can be resolved using the SIP Subscribe/Notify mechanism, whereas an HTTPs reference can be resolved by performing a HTTPs POST or GET request. Both mechanisms provide a Presence Information Data Format - Location Object (PIDF-LO), which is specified by RFC5491 (https://tools.ietf.org/html/rfc5491).

Further information regarding Location by Reference can be found in RFC6442 (https://tools.ietf.org/html/rfc6442).

1.3.2 Location by Value

Location by Value is transported as part of the SIP body. This way, it is immediately available and does not need additional resolving. The Geolocation header indicates the availability of a location in the body by having a reference to the content id (cid).

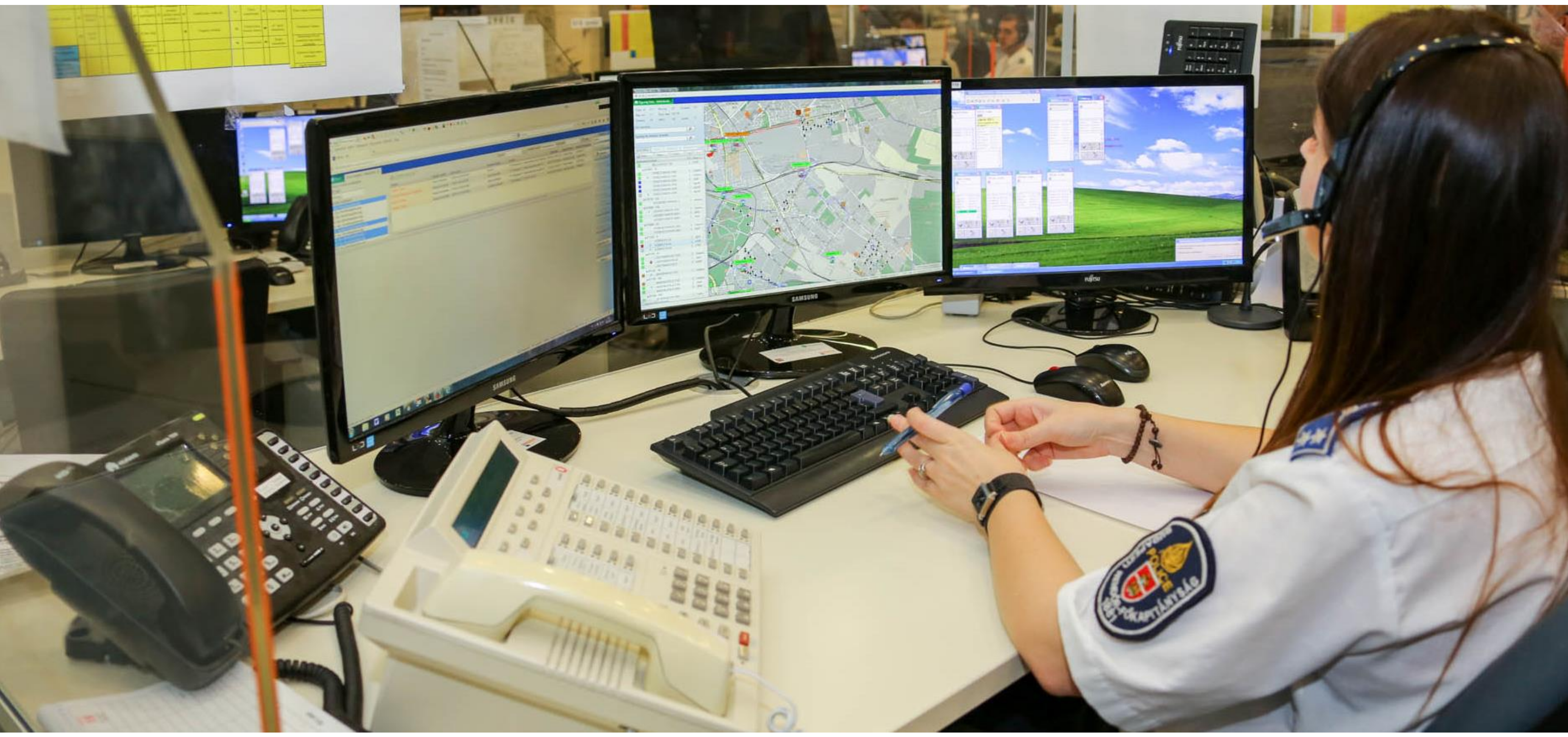
Example:

```
Geolocation: <cid:+43123456789@mobile.network.provider.com>
```

The location as such is encoded using PIDF-LO, with the cid in the Geolocation header matching the Content-ID.

Example:

```
Geolocation: <cid:+43123456789@mobile.network.provider.com>
...
Content-Type: multipart/mixed; boundary=boundary1
Content-Length: ...
--boundary1
Content-Type: application/sdp
      ...Session Description Protocol (SDP) goes here
--boundary1
Content-Type: application/pidf+xml
Content-ID: <+43123456789@mobile.network.provider.com>
...Presence Information Data Format  - Location Object goes here
```



2. NG112 ARCHITECTURE

The Emergency Services IP Network hosts multiple core components specified by the NG112 architecture. These include the following:

- Border Control Function (BCF)
- Emergency Call Routing Function (ECRF)
- Emergency Services Routing Proxy (ESRP)
- Location Information Service (LIS)

Public Safety Answering Points are technically outside the ESInet but connect to it and interface with the different core components.

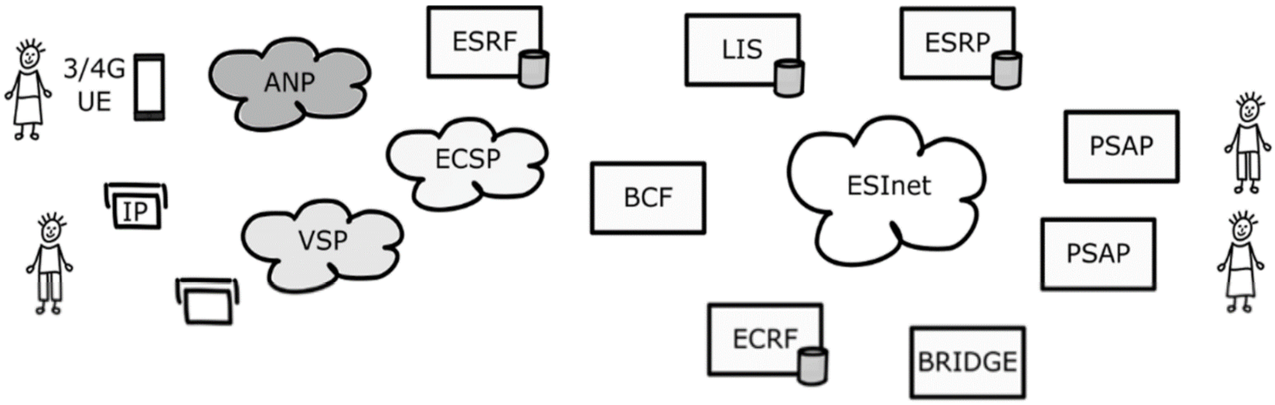


Figure 1: High level functional architecture (ETSI TS 103 479)

Location information within the ESInet is mainly used for Routing purposes. Elements within the NG112 architecture preserve or add the Geolocation header and the location included in the SIP body when processing and forwarding emergency communications to the next element. This way, it is ensured that all elements, including the PSAP, have access to the location information.

2.1 Emergency Communications within NG112

This section describes the process for emergency communications, location-based routing, the involved core components and decision points within the NG112 architecture.

2.1.1 Border Control Function (BCF)

The Border Control Function (BCF) is the entry point (point-of-interconnect) to an ESInet. It can be seen as a firewall and additional security layer protecting the core elements. Once an emergency communication is received at the BCF, it is forwarded to a well-known Emergency Service Routing Proxy (ESRP).

2.1.2 Emergency Service Routing Proxy (ESRP)

The ESRP with its corresponding Policy Routing Function (PRF) provides the powerful and dynamic routing capabilities of the NG112 architecture. Multiple rules are evaluated in order to determine the most appropriate PSAP or next hop to forward the emergency communication to. Those rules can include the evaluation of the location, the desired service type (e.g. police, fire, ambulance, etc), day/night time shifts, states of the PSAPs, type of application, type of emergency communication etc.

Usually one of the highest priority rules of an ESRP is to retrieve the responsible PSAP based on the location provided in the initial communication setup and the requested service type. To achieve this, the ECRF performs a Location-to-Service Translation (LoST) query against the Emergency Call Routing Function (ECRF).

Based on the PSAP or next hop provided by the ECRF, it will evaluate another set of rules and forward the emergency communication accordingly.

2.1.3 Emergency Call Routing Function (ECRF)

As described above, the ECRF is queried by the ESRP to provide information about which service (e.g. PSAP) is responsible for a specific service type (e.g. police) at a specific location. This query is performed using the LoST interface, more specifically, using the findService request.

A findService request includes the desired service (e.g. urn:service.sos.police) and the location for which this service should be resolved.

```
<?xml version="1.0" encoding="UTF-8"?>
   <findService
     xmlns="urn:ietf:params:xml:ns:lost1"
     xmlns:p2="http://www.opengis.net/gml"
     serviceBoundary="value"
     recursive="true">
     <location id="6020688f1ce1896d" profile="geodetic-2d">
       <p2:Point id="point1" srsName="urn:ogc:def:crs:EPSG::4326">
          <p2:pos>50.83396 4.35206</p2:pos>
       </p2:Point>
     </location>
     <service>urn:service:sos.police</service>
   </findService>
```

To respond to findService requests, the ECRF uses its internal geographical data and mappings to identify the responsible service. The example below shows an example configuration of the ECRF mappings for Austrian states Vienna and Carinthia.

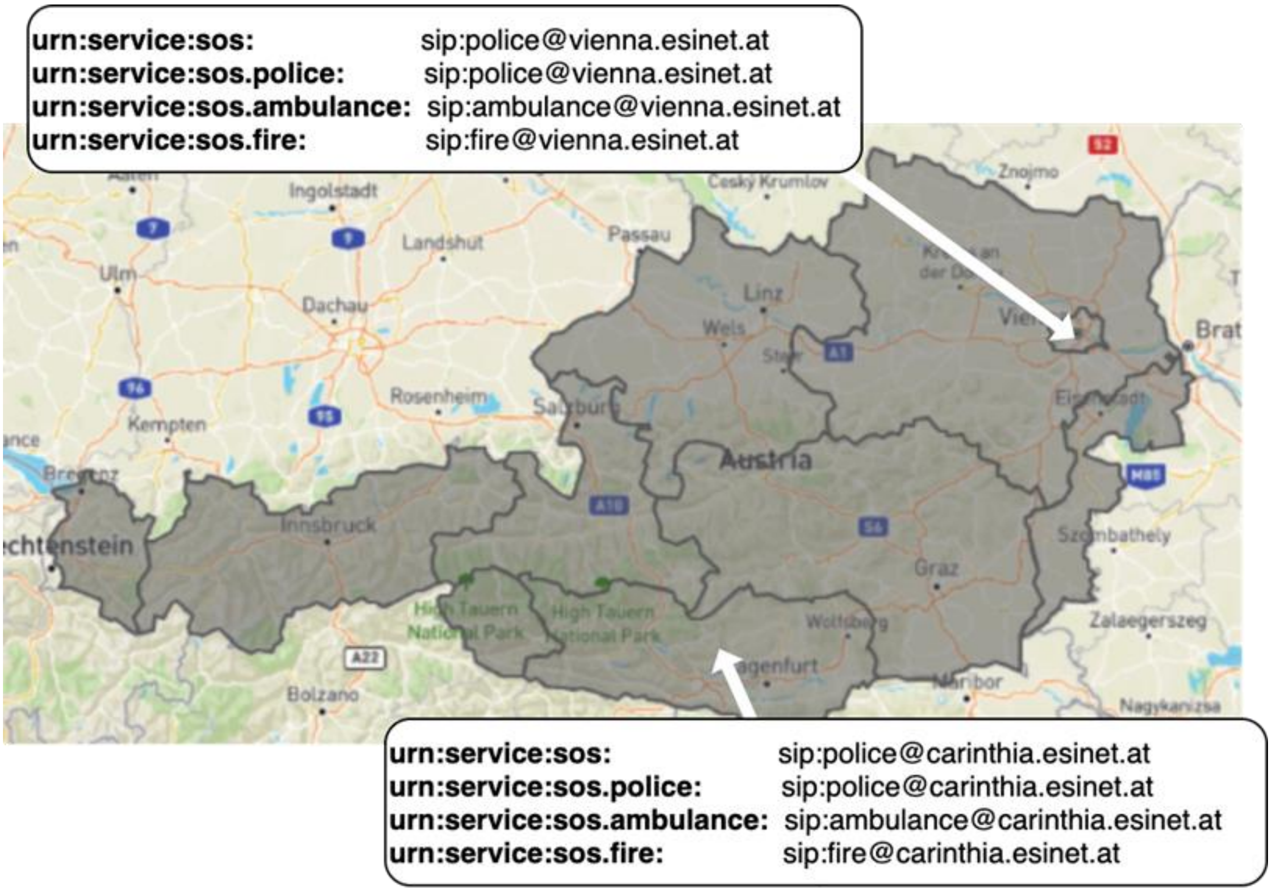


Figure 2: Example ECRF Mappings for Vienna and Carinthia, Austria

```
<?xml version="1.0" encoding="UTF-8"?>
<findServiceResponse>
    <mapping
            expires="2025-01-01T01:44:33Z"
            lastUpdated="2020-11-01T01:00:00Z"
            source="authoritative.example"
            sourceId="5da818d352f4e3fa4b6f4fea8a02281">
        <service>urn:service:sos.police</service>
        <serviceBoundary profile="civic">
            <civicAddress>
                <country>AT</country>
                <A1>Vienna</A1>
                <A3>Vienna</A3>
                <PC>1190</PC>
            </civicAddress>
        </serviceBoundary>
        <uri>sip:police@vienna.esinet.at</uri>
        <serviceNumber>112</serviceNumber>
    </mapping>
    <locationUsed id="317b8dr815d0edd4h"/>
</findServiceResponse>
```

Example findServiceResponse (without namespaces)

2.1.4 Location Information Service (LIS)

The Location Information Service can be seen as an additional service that is able to provide location information for a specific entity (e.g. a mobile phone) via the HTTP-enabled Location Discovery (HELD) interface, which uses PIDF-LO to represent location information.

The LIS also provides subscribe/notify mechanisms, so that functional elements can subscribe for location information of an entity and a notification is triggered whenever the entity's location changes.

The LIS can be used by an ESRP to identify the location of the emergency communication Initiator. This might be necessary if the Initiator does not include any location information in the initiation of the emergency communication.

As an example, the LIS can provide an internal lookup mechanism for landline phone numbers to their registered location. Once the ESRP receives an emergency communication via a landline phone number, it can query the LIS for the phone number's registered address and route accordingly.

In addition, the LIS can act as an endpoint for Advanced Mobile Location (AML) as described in section "Relation to Advanced Mobile Location". It provides the corresponding endpoints for SMS and/or HTTPS and provides the location information to PSAPs via HELD. This allows PSAPs to use the standardised HELD interface to retrieve location information, and the different protocols and mechanisms to retrieve locations from various sources can be implemented at the LIS for transparent usage by PSAPs.

2.2 Public Safety Answering Point (PSAP)

The PSAP is connected to the ESInet and receives emergency communications via the ESRP. As described in the previous section, the ESRP forwards emergency communications, which include location information either by reference or by value, to the most appropriate PSAP.

As described in the section Transport of a Location, PSAPs either get the location "pushed" via the emergency communication setup (Location by Value) or dereference the location (Location by Reference), which is more of a "pull" approach.

After the establishment of the emergency communication, location information updates can be sent directly to the PSAP using the SIP protocol. Additionally, the PSAP might subscribe at the Location Information Service to receive notifications every time the location updates. As a simple alternative to the notify/subscribe mechanism, PSAPs could also request location information from the LIS at certain intervals. This "polling" approach and the corresponding intervals, must be chosen wisely, to prevent overloading the LIS.

The most important aspect however is that the representation of the location information always uses the same standard, namely PIDF-LO. This way, additional location mechanisms can be implemented and added to the ESInet and PSAPs can transparently make use of that information.

3. LOCATION COMPARISON

This section compares the current and NG112 enabled location mechanism. Therefore, it is important to understand that the NG112 architecture provides the foundation for additional location mechanisms. It "only" acts as an enabler by providing additional data capabilities for emergency communications and does not provide location mechanisms on its own. Location information still needs to be determined by a certain entity.

The NG112 architecture enables the transport and correlation of that information to the most appropriate PSAP. The accuracy of location depends on the actual mechanism of location. Therefore, NG112 as such does not automatically increase the accuracy, but it provides the underlying mechanisms needed to enable location mechanisms that provide a more precise location information.

3.1 Emergency Communications via Mobiles

Emergency communications initiated via mobile phones usually use a mobile network as the Medium. Technically, mobile phones connect to a mobile network via cell towers. Independent of the location mechanisms, the mobile network should provide the available locations when forwarding the emergency communication to the ESInet.

3.1.1 Current Location Mechanisms

Currently, most emergency communications from mobile phones are initiated via GSM. As GSM does not provide the capabilities to send additional data within the emergency communication, the location mechanisms are limited to the capabilities of the network.

Additional over the top mechanisms like Advanced Mobile Location can be implemented to compensate for this limitation but are not naturally recognised by the network as emergency communications, which results in different challenges.

Cell Tower Location

The mobile network knows the cell tower that the mobile is connected to. Cell towers have a fixed physical location and a certain coverage area.

Since the mobile is connected to the cell tower, it is known to be in that cell tower's coverage area. The accuracy depends on the coverage area and it may not be very high. This is especially true in the countryside, where cell towers might have a coverage area in the range of 5km and more

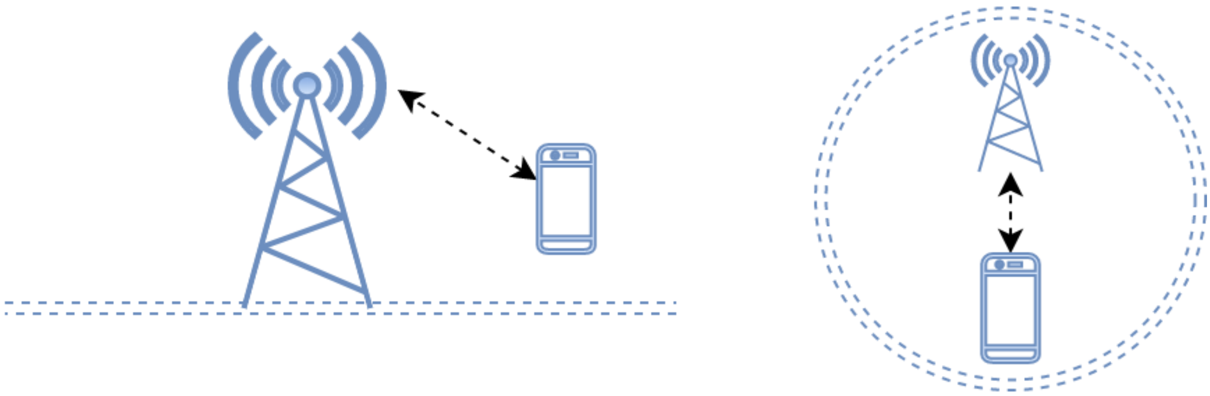


Figure 3: Cell Tower Location

Cell Tower location is available immediately since it is the actual physical access for the mobile. However, due to relatively wide range of coverage, location might only be used for routing the emergency communication. Another issue occurs when cell tower coverage area crosses certain responsibility boundaries (e.g. country/state/region borders). Emergency communications are then routed to a PSAP that is not actually responsible for handling the call.

Aspect	Value
Location Type	Geodetic
Accuracy	Low
Time Delay	None / Neglectable
Main Purpose	Routing

Cell Tower Triangulation

Cell Tower Triangulation uses the concepts from Cell Tower Location but in combination with multiple cell towers.

Even though a mobile is connected to one cell tower, multiple cell towers might be in reach with different signal strengths. Based on that information, the mobile network can calculate the area of the mobile via the triangulation of the cell towers, their physical location and coverage as shown in figure 4 and 5.

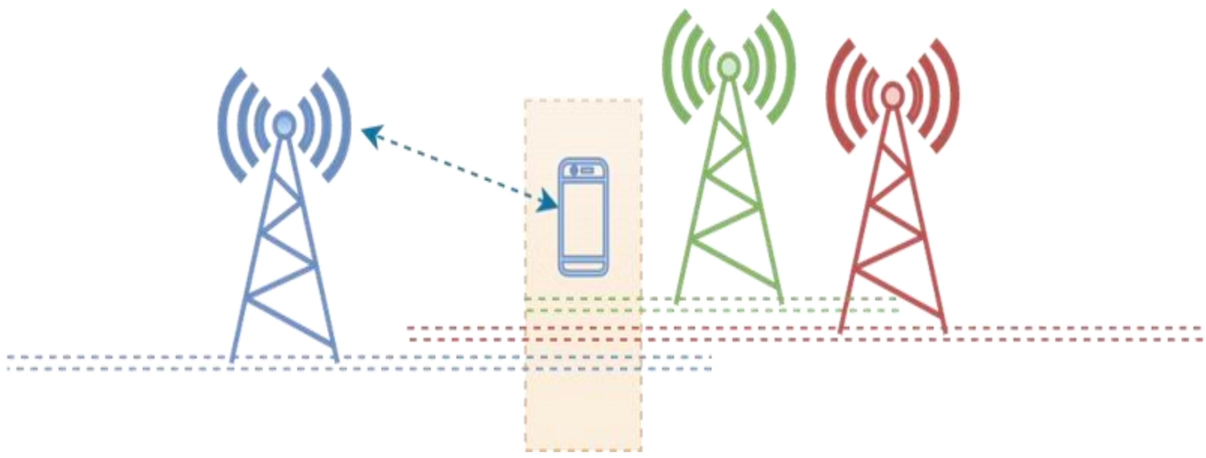


Figure 4: Example Triangulation

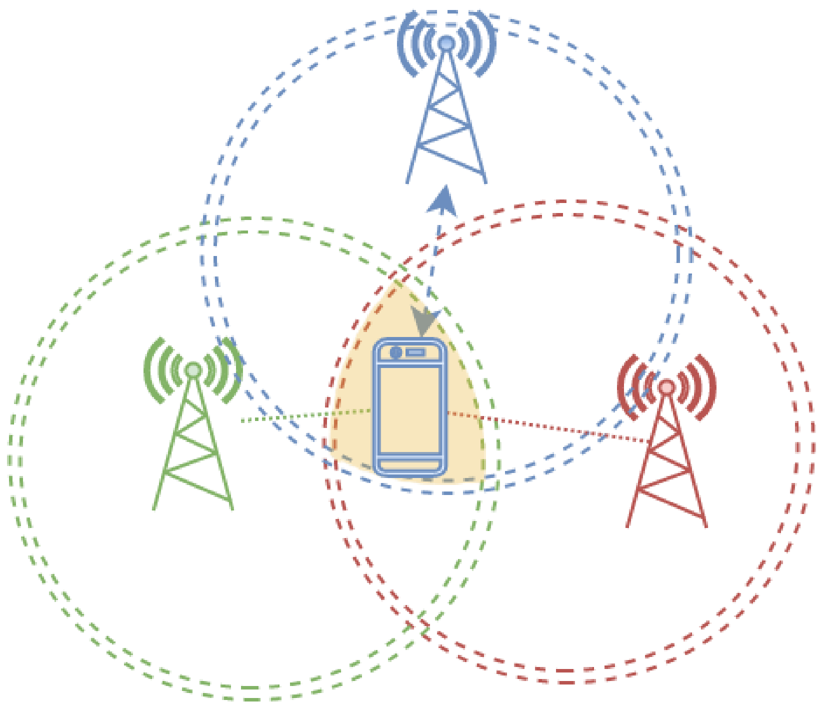


Figure 5: Example Triangulation

Aspect	Value
Location Type	Geodetic
Accuracy	Medium (depending on the number of cell towers / coverage area)
Time Delay	Medium
Main Purpose	Dispatch

Advanced Mobile Location

Advanced Mobile Location describes the mechanism of how to transfer a location determined by the mobile. When an emergency call is initiated, it sends the location via SMS or HTTPs to a defined endpoint. The message formats are defined in TS 103 625.

Advanced Mobile Location does not add new location mechanisms nor affect the accuracy of such mechanisms. AML simply uses the mobile phone's capabilities to determine its location and provides corresponding message formats to transfer it.

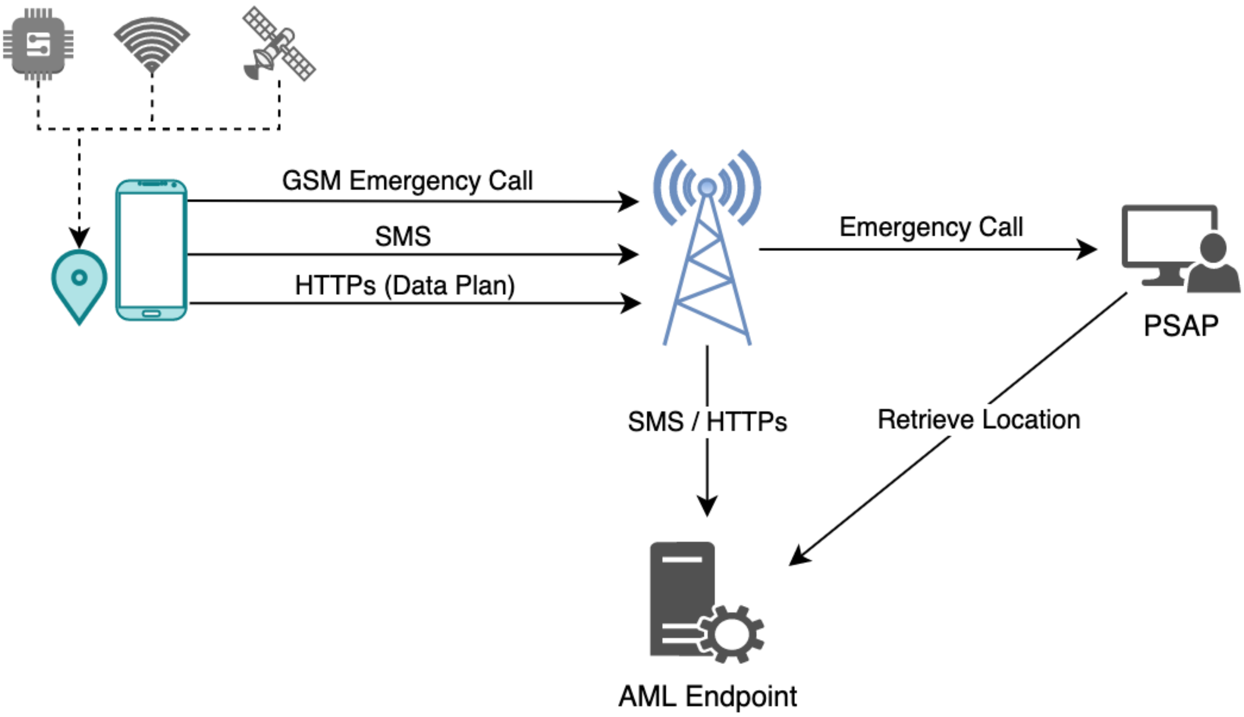


Figure 6: Advanced Mobile Location

Aspect	Value
Location Type	Geodetic
Accuracy	High
Time Delay	Low-Medium
Main Purpose	Dispatch Only

3.1.2 NG112 Location Mechanisms

The NG112 architecture is based on Voice over LTE (VoLTE) and the Session Initiation Protocol (SIP) for emergency communications. This allows additional data to be attached to the emergency communication directly, without the need for any over the top technology. Although this document's main focus is on the different location mechanisms, it is worth mentioning that VoLTE is the prerequisite to enable multimedia emergency communications including speech, text and video (Video over LTE) capabilities.

All the above-mentioned location mechanisms can be used. Additionally, the NG112 architecture enables the transfer of mobile derived locations when establishing the emergency communication. The same concepts can also be reused to include additional non-location data, such as the minimum set of data in NG eCall, etc.

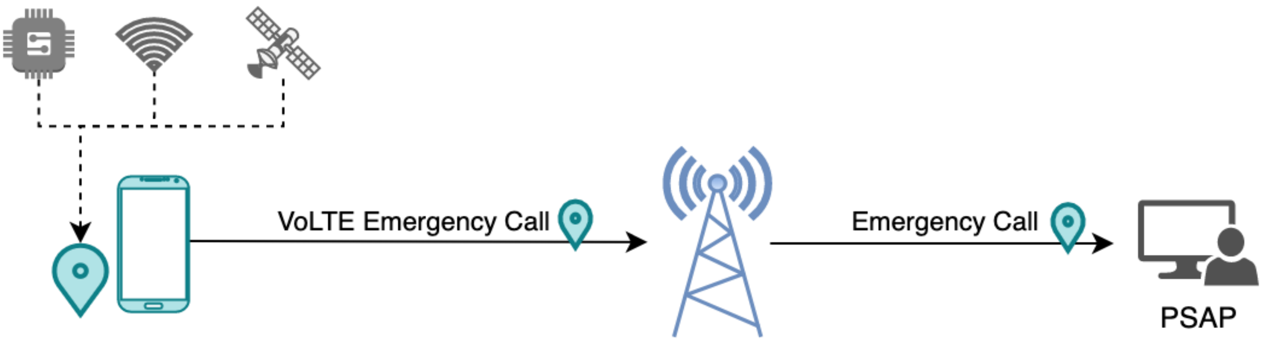


Figure 7: VoLTE Emergency Call

Since the location is immediately available during the initiation of the emergency communication, this allows more precise locations to be used for routing, instead of only for dispatch.

Further information regarding location transmission can be found in ETSI ES 203 283[1] and in ETSI TS 129 572[2].

Aspect	Value
Location Type	Geodetic
Accuracy	High
Time Delay	Low
Main Purpose	Routing & Dispatch

Location Updates

Since VoLTE uses the SIP protocol, the PSAP can use the publish/subscribe mechanism to subscribe to changes in the location. The mobile will then send notifications when the location changes significantly (e.g. >10m).

1 https://www.etsi.org/deliver/etsi_es/203200_203299/203283/01.01.01_60/es_203283v010101p.pdf

2 https://www.etsi.org/deliver/etsi_ts/129500_129599/129572/16.05.00_60/ts_129572v160500p.pdf

3.2 Emergency Communications via Legacy Fixed Line Telephony

Landline telephones are usually bound to a fixed location. Therefore, the location when using landlines to initiate an emergency communication is probably the most straightforward one.

The telephone provider knows the location of the telephone connection. Using the NG112 architecture, the telephone provider adds this information when forwarding emergency communications to the ESInet. Additionally, this lookup could be implemented in the Location Information Service, so that PSAPs can request the location as well.

Aspect	Value
Location Type	Civic
Accuracy	High
Time Delay	None / Neglectable
Main Purpose	Routing & Dispatch

3.3 Emergency Communications via Apps

Mobile applications can extend the capabilities of the "native" mobile phones when it comes to emergency services. Mobile applications allow additional logic to be included, IoT devices to be integrated, and information to be added to increase situational awareness (e.g. by sending images, sensor data, etc.). They usually use the mobile phone's capabilities and APIs to initiate an emergency communication and to retrieve the location.

3.3.1 Current Location Mechanism

Emergency applications may use the mobile phone APIs to trigger an emergency communication, which results in a GSM emergency call. Additional data is sent using an over-the-top approach, while using the mobile phone only as an access point to the internet to interface with the vendor-specific backend services. Mobile applications can use the same capabilities as Advanced Mobile Location to determine the location.

As the location information cannot be transmitted within the GSM emergency call, vendors often provide proprietary interfaces, applications, or platforms for PSAPs to retrieve that information, which therefore can only be used for dispatching.

Aspect	Value
Location Type	Geodetic
Accuracy	High
Time Delay	Medium
Main Purpose	Dispatch

Since mobile applications might trigger a GSM emergency call in parallel, all the mechanisms mentioned in Emergency Communications via Mobiles apply.

3.3.2 NG112 Location Mechanisms

Using VoLTE, the mobile phone can automatically determine its location and transmit it during the initiation of the emergency communication. Mobile applications can still provide value in the form of additional logic to determine when such a VoLTE emergency communication shall be triggered (e.g. fall detection, crash & accident detection). Mobile applications can provide different user interfaces and integrate with other sensors or systems.

Similar to the current integration, mobile applications can trigger VoLTE emergency communications using the corresponding APIs.

In addition, the APIs should provide the capabilities to add additional data as shown in figure 8.

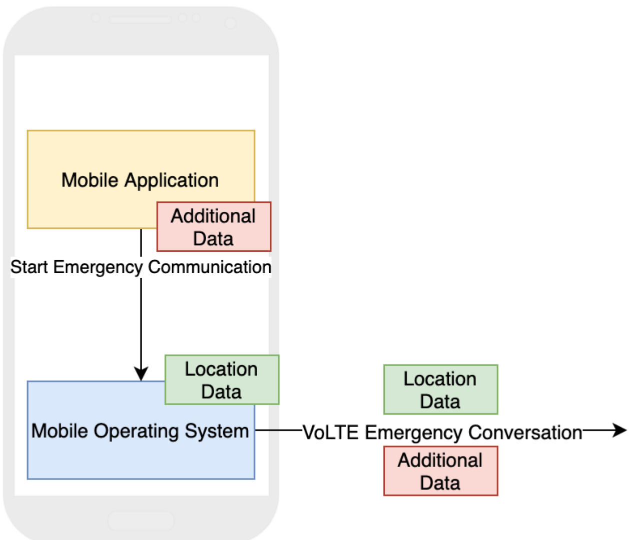


Figure 8: VoLTE Emergency Call

Since mobile applications might trigger VoLTE emergency communications while integrating their additional data, all the mechanisms mentioned in Emergency Communications via Mobiles apply.

Aspect	Value
Location Type	Geodetic
Accuracy	High
Time Delay	Low
Main Purpose	Routing & Dispatch

3.4 Emergency Communications via Cars

The eCall in modern cars automatically triggers an emergency call in case of an accident and transmits relevant data, including location information.

3.4.1 Current eCall

The current eCall transmits the location information as part of the minimum set of data (MSD). The data is transmitted inband as part of the voice connection and is therefore only available after the emergency call is established and cannot be used for routing purposes.

Aspect	Value
Location Type	Geodetic
Accuracy	High
Time Delay	Medium-High (only available after communication establishment)
Main Purpose	Dispatch

Since the eCall is based on a 2G/3G emergency call, all other mechanisms mentioned in section Emergency Communications via Mobiles are used to route the eCall. It is also worth mentioning that the amount of data that can be transferred “inband” is quite limited.

3.4.2 Next Generation eCall

The Next Generation eCall (NG eCall) is based on VoLTE. NG eCall using VoLTE can transmit the location information directly when initiating the emergency communication. Additional information of the minimum set of data can also be added.

Aspect	Value
Location Type	Geodetic
Accuracy	High
Time Delay	Low
Main Purpose	Routing & Dispatch

4. SUMMARY

Location in emergency situations is a critical aspect for fast and efficient emergency services. This includes routing to the most appropriate Public Safety Answering Point and providing the most accurate location for dispatching assistance.

As described, there are multiple methods for location, varying in their accuracy, time to determine and their main purpose within an emergency communication. Since each method has its own specific restrictions and challenges, there is no one-fits-all solution. Therefore, it is important to enable the transmission of multiple locations and provide the capabilities to evaluate their plausibility.

NG112 and its core services provide a blueprint for next generation emergency services, defining standardised ways of transmitting location information as well as other additional data to raise situational awareness and provide efficient, interconnected, and interoperable emergency services.