# Developing an Interoperability Script for Alert Management Systems


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# Developing an Interoperability Script for Alert Management Systems

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Due to the changing global climate in recent years, disaster management systems have increased their efforts to facilitate data gathered from calamities. However, these systems are grossly limited and do not integrate well with other disaster management applications and tools. Issues arise regarding communication, standardization and local deployment. Interoperability among these systems is essential. It is the intent of this study to demonstrate interoperability of these technologies using an emergency alert information script. The thesis will focus on how to extend Sahana and its services to include other functionalities that are relevant to crisis response. The results of the study will reveal how to present these technologies as one service.

General Terms: Alert Management, Common Alerting Protocol, Interoperability

Additional Key Words and Phrases: Crisis response, Google Maps, Sahana

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## 1. INTRODUCTION

In light of recent events and disasters, people have taken to social networking and micro-blogging sites to update friends and loved ones regarding their safety. Mobile device usage has become ubiquitous that news, updates can be disseminated within seconds. However, because of the chaotic nature of disasters, crucial information can be overwhelming and confusing. There is a growing concern for the interoperability of available web services and porting them to different platforms, both stand-alone desktop systems and mobile. By solving platform dependence, users need not concern themselves about device support, and by moving the application to the web, users (developers and organizations) can access the service using any internet-capable device.

Common Alerting Protocol or CAP is an XML implementation that uses an easy-to-use and well-tested library to create messages. The CAP data structure is backward-compatible with existing alert formats including the Specific Area Message Encoding (SAME) used in Weatheradio and the broadcast Emergency Alert System as well as new technology such as the Commercial Mobile Alert System (CMAS), while adding capabilities including:

Flexible geographic targeting using latitude/longitude "boxes" and other geospatial representations in three dimensions, multilingual and multi-audience messaging, phased and delayed effective times and expirations, enhanced message update and cancellation features, template support for framing complete and effective warning messages, digital encryption and signature capability, facility for digital images, audio, and video.

The Sahana Disaster Management is a tool conceptualized to enable organizations prepare for disaster, as well as to make relief operations efficient and fast. Sahana has numerous modules geared to monitor relief aid, missing persons and rescue requests. The Sahana information management system is currently distributed under the GNU Lesser General Public License and is currently used by countries worldwide in their individual disaster management organizations.

Most of these technologies are widely used in a web-based context. The proponents aim to create a script that will demonstrate interoperability of information exchange by using Common Alerting Protocol.

## 1.1 Objectives

The objective of this thesis is to investigate how multiple disaster management systems and tools could share data from a reliable source. This is in congruence to pressing issues regarding standardization and diversity of independent systems in the context of information management and crisis response. Initial findings on a comparative study of existing disaster management tools and systems, both open source and proprietary implementations have revealed that systems have common functionalities but they are not uniformly similar. Some systems have more features than some concerning support and functionalities. The proponents conducted an evaluation of existing technologies that have exhaustive documentation and already demonstrated interoperability on some level with other systems (not necessarily disaster management). Another aim is to enforce standardization for alert messages. The script will parse alerts from an alert messaging system that follows widely accepted industry standards. This ensures that message encoding is uniform.

This study will involve the creation of two systems that will make use of CAP messaging as well as integration of such services within the Sahana framework. This will demonstrate how several systems will interact with each other, exchange information and present the alerts in a way that is cohesive with the purpose of each system.

## 1.2 Significance of the Study

The purpose and significance of this study is to design a script that will allow rapid and easy development of a broad range of applications that can make use of the data gathered. There is a need to address concerns regarding interoperability and dependence of existing disaster management systems to their chosen platform. Studies conducted by Google.org has shown that statistics from "search data for several natural disasters has consistent trends, that while in some cases, internet access is restricted due to infrastructure failures, ISPs continue to provide connectivity. The findings show just how resilient the internet can be in times of crises, compared to other infrastructure". The Common Alerting Protocol (CAP) provides an open, non-proprietary digital message format for all types of alerts and notifications. The CAP format is compatible with emerging techniques, such as Web services, as well as existing formats including the Specific Area Message Encoding (SAME) used for NOAA Weather Radio and the Emergency Alert System, while offering enhanced capabilities that include:

- Flexible geographic targeting using latitude/longitude shapes and other geospatial representations in three dimensions;
- Multilingual and multi-audience messaging;
- Phased and delayed effective times and expirations;
- Enhanced message update and cancellation features;
- Template support for framing complete and effective warning messages;
- Facility for digital encryption and signature capability; and,
- Facility for digital images and audio.

Key benefits of CAP will include reduction of costs and operational complexity by eliminating the need for multiple custom software interfaces to the many warning sources and dissemination systems involved in all-hazard warning. The CAP message format can be converted to and from the "native" formats of all kinds of sensor and alerting technologies, forming a basis for a technology-independent national and international "warning internet." Although primarily designed as an interoperability standard for use among warning systems and other emergency information systems, the CAP Alert Message can be delivered directly to alert recipients over various networks, including data broadcasts. Location-aware receiving devices could use the information in a CAP Alert Message to determine, based on their current location, whether that particular message was relevant to their users.

### 1.3 Scope and Limitations

For the purposes of this study, the proponents will use the following tools:

a. Google Maps API

b. Common Alerting Protocol

c. Sahana FOSS

The proposed script should be able to demonstrate interoperability of services by integrating Sahana with a script for polling capability. This will facilitate data exchange with two systems with the use of CAP messaging. The systems will receive and send CAP messages with each other, making sure that the transfer is two-way, and display the information gathered from CAP within the context of the specific system using SimpleXML.

The script should follow certain protocols for the parameters of issuance of alerts to ensure that information will not be altered in any way. Since some of the APIs used in this research are web-based services, the script will rely on an internet connection for access and updates. The thesis will also focus on the data exchange aspect of interoperability. An ontology will be used from UN-OCHA and a translation will be derived for CAP. Implementation of load balancers for servers and peer to peer replication via Gossip Protocols and deterministic algorithms are beyond the scope of this study.

## 2. REVIEW OF RELATED LITERATURE/WORK

**a. Architecture of Interoperable Information Systems. An Enterprise Model-Based Approach for Describing and Enacting Collaborative Business Processes – Jorg Ziemann**

This paper explains that people often misinterpret alert messages and act inappropriately because they have not fully understood the message. Most especially when these messages are in short-hand or sent using text messaging. He writes that "challenges in addressing at makes and brands when alerting for mobile devices vary greatly between iOS, Android, Windows, Symbian and so on". Developers need to find the most effective way to display information from the alert. First, it must reach the people involved. Generic applets can be developed to display necessary data that can be accessed via the web. It can then be customized for country context based on the country's CAP profile. The customized applet can be used to deliver, over-the-air, alerts to subscribers. Thereafter, at the subscriber's discretion, they can further customize which alerts they would like to receive based on threat levels, types of calamities, location, etc.

**b. Symbols in Alerting – Nuwan Waidyanatha**

Second, it must be clear and unambiguous. Google Public Alerts is an alert feed that aggregates CAP messages all over the world – labels each alert with a common circle symbol with letters A, B, C... and so on. Letters would be scattered all over the map corresponding to the affected areas. This makes it hard to read and follow. If those messages were pegged with a symbol associated with the hazard it would be much faster for the human eye to filter through the list of messages. Then the challenge is mapping that description with the symbol to the location on the map because the map could be filled with multiple Tornado icons, for example. It could possibly be overcome by superimposing a number or character, like A, B, C... which they are already doing. However, Google uses symbolism with their hazard specific alerting information pages such as with Weather Hazards, where the color coding represents the potential impact.

c. **When and How ICT Interoperability Drives Innovation - Urs Gasser and John Palfrey**

Lastly, there must be a standard that is backwards-compatible with existing emergency alert protocols. Elizabeth Klute, in one of her alerting workshops for OASIS entitled 'XML and Emergency Management', stresses that initiatives must be exercised to research and develop a framework that is in-line with the CAP standard.

Time to fully grasp the functional requirements may be lengthy, and design parameters, process variables also need to be understood fully. However, Klute has also formed a methodology for a potential pilot study. She suggests that the pilot study would be done in two parts:

1. technology developments with CAP and for mobiles

2. develop a set of symbols associated with linguistics and semantics.

Thereafter, simplicity of design is a major factor in determining the effectiveness of such a program. Sahana would certainly be a good platform to drive this initiative.

d. **Process and Metrics for Measuring Interoperability Cost and Risk – Nathan Hartman, John Horst, George Wong**

The intent of the interoperability framework is to provide the context for identifying and debating interoperability issues to advance actions that make integration within this complex system easier. The framework recognizes that interoperability is only achieved when agreement is reached across many layers of concern.

These layers span the details of the technology involved to link systems together, to the understanding of the information exchanged, to the business processes and organizational objectives that are represented in business, economic, and regulatory policy.

e. **Enterprise Interoperability Framework – David Chen**

Research on interoperability is not only a matter of removing barriers but also in the way in which these barriers are removed. According to ISO 14258 (1999), there are three basic ways to relate entities (systems) together to establish interoperations:

i. Intergrated approach – there exists a common format for all models. This format must be as detailed as the models. The common format is not necessarily a standard but must be agreed by all parties to elaborate models and build systems.

ii. Unified approach – there exists a common format but only at a meta-level. This meta-model is not an executable entity as it is in the integrated approach but provides a mean for semantic equivalence to allow mapping between models.

iii. Federated approach – there is no common format. To establish interoperability, parties must accommodate on the fly. Using federated approach implies that no partner imposes their models, languages and methods of work. This means that they must share an ontology.

### f. Emergency Information Interoperability Frameworks – W3C Incubator Group Report

In a general dictionary sense, ontology refers to efforts to represent knowledge by categorizing and characterizing concepts, and by showing the relationships between them. From a more practical point of view, the term refers to the practice of identifying the concepts and relationships used in a domain, which then enables reasoning over the objects in the domain based on these concepts and relationships.

The need to move towards a common ontology methodology is a major goal to meet, in order to address the need for information interoperability in emergency management. Having stated this, it is also one of the hardest goals to meet, as the necessary consensus process across all the stakeholders will be a significant challenge. Moreover, having a single domain ontology shared by various applications may not be feasible in most cases. This is due to the fact that useful domain ontologies do rely on the particular task at hand and on the organization that develops them. This distributed nature of ontology development has led to a large number of ontologies covering the same or overlapping domains. Various organizations develop their own ontologies without fully understanding each other's. Hence ontology heterogeneity becomes the first problem that needs to be solved when designing an ontology-based system. As such, ontology engineers face the problem of integrating different ontologies, either to support communication amongst existing and new domains, or to enable interoperability across heterogeneous systems. Ontology mapping is the process of identifying the correspondences (mappings) between the concepts of two ontologies. It aims to solve the syntactic and semantic heterogeneity problem, and can be done (semi-)automatically or manually with the help of ontology experts.

One of the key challenges in creating ontologies is where to begin the collection of the semantics. The U.S.-based National Information Exchange Model has collected all the current XML-based standards and collated them to provide a comprehensive set of semantics, not only for emergency management, but also for immigration, infrastructure protection, intelligence, international trade, justice, and person screening. The disadvantage of this model is that it is simply a union of a large overlapping set of semantics, with no overarching model or abstract framework to guide interoperability.

## 3. TECHNICAL BACKGROUND

For the purpose of this study, interoperability is contextualized within an alert management system, or the alert module of a disaster management system. However, it is important to understand that to achieve semantic interoperability, syntactic interoperability must also be addressed. This problem is solved with the use of a protocol which is widely accepted within a specific context.

With the use of CAP and XML, the proponents have solved the syntactic aspect of interoperability. Google Public Alerts is a newsfeed that publishes information written in CAP about the hurricanes, storms, earthquakes, etc. that are currently happening all over the world. Users can limit search results to local events but this is still in a limited release.

Google Maps have extensive documentation and open libraries that will make research and implementation easier. They also have an open-policy for developers to create new applications/applets based on their existing services. Upon careful examination of their standards, and at their recommendation, other alert systems (SAME, EAS, CMAS), is scrapped in favor of CAP (Common Alerting Protocol).

Google.org is pushing for the integration of CAP in order to standardize the distribution of alert information on the web. With CAP, data sharing is secure and automated by trusted sources during emergencies. Meanwhile, Sahana FOSS is a web-based collaboration tool that addresses the common

coordination problems during a disaster. Their modules include managing volunteers, tracking relocation centers, finding missing people and managing relief goods and aid.

It is available for downloaded and easy to configure, as well as offering support for third party libraries. The proponents will examine how to extend Sahana FOSS with the existing libraries available with CAP. Scalability and open-standards are the deciding factors of which technologies to use, as well as the context.

The lack of shared vocabulary is acknowledged as one of the causes for knowledge disconnectedness on the web, and is a common, major problem in all sectors. The use of different terms, definitions and concepts is one of the central causes of lack of semantic integration and divergence, therefore one of major obstacles to leveraging synergy and allowing collective intelligence to be catalyzed. Lexical and semantic distance may arise from differences among:

a. Terms used by different agencies in the same operational field

b. Terms used by different agencies in different operational fields

c. Terms used by agencies in different jurisdictions, across the same and different operational fields

As an example, one of the documented terms in emergency information systems is victim. Victim is a widespread English language term in use in emergency management operations worldwide. There are indications that some people affected by adverse events actually resent being called 'victim', as this conveys an image of passivity, helplessness and impotence.

While many would agree that people impacted by adversity and in need of emergency aid have higher priorities than disputing preferred naming conventions, it could be argued that the word 'victim' in itself is not necessarily a meaningful word, and that enhanced terminological correctness and sensitivity is desirable, where possible.

Therefore the term victim can be semantically mapped from UNOCHA to CAP into a preferred context-neutral term, such as 'Affected Person', which is the current naming convention for this entity in W3 Coordination Information Model.

Therefore, a semantic cluster identifier for "person" may include:

a. Recipient of aid

b. Beneficiary of aid

c. Client/patient/user

d. Displaced Person

e. Victim

Similar processes apply for many terms used conventionally in the emergency management sector, for example, 'disaster'. During open community discussion, it emerged that the term 'disaster' is not necessarily representative of the range of adverse events that constitute an emergency, and it may have some undesired connotations. Therefore, a semantic cluster identifier for "event" may include.

a. Occurrence

b. Incident (used by OASIS)

c. Emergency

d. Disaster

For global interoperability we need some harmonized vocabularies and glossaries. One example is the UNOCHA Glossary of Terms. We can see traces of the challenge discussed here in the set of defined terms, as there is no entry for "victim". Instead there are some related terms such as "actor," which mentions the victim role in a simulation context:

Actor: Individual simulating a victim, victim family, media, perpetrator, or other person within the exercise scenario to prompt realistic action/reaction from the exercise players.

On the other hand CAP has additional items such as "alert," which discusses related terms (e.g. "advisory").

Alert: A notification category between "advisory" and "activation" that provides urgent information and indicates that system action may be necessary. An alert can be used for initial notification that incident activation is likely, and for ongoing notification throughout an incident to convey incident information and directed or recommended actions (see "advisory" -- "alert" -- "activation" for contrast between the other notification categories).

Notification: Information distributed to relevant personnel that contains important information regarding an actual or potential hazard impact and the response status of the organization. There are generally four categories of notification: update, alert, advisory, and activation.

In the National Incident Management System (NIMS) glossary [FEMA] in the U.S., we find a specific definition of "emergency":

Emergency: Any incident, whether natural or man-made, that requires responsive action to protect life or property. Under the Robert T. Stafford Disaster Relief and Emergency Assistance Act, an emergency means any occasion or instance for which, in the determination of the President, Federal assistance is needed to supplement State and local efforts and capabilities to save lives and to protect property and public health and safety, or to lessen or avert the threat of a catastrophe in any part of the United States.

Clearly, this definition will not work outside the U.S. However, other useful terms found in NIMS include:

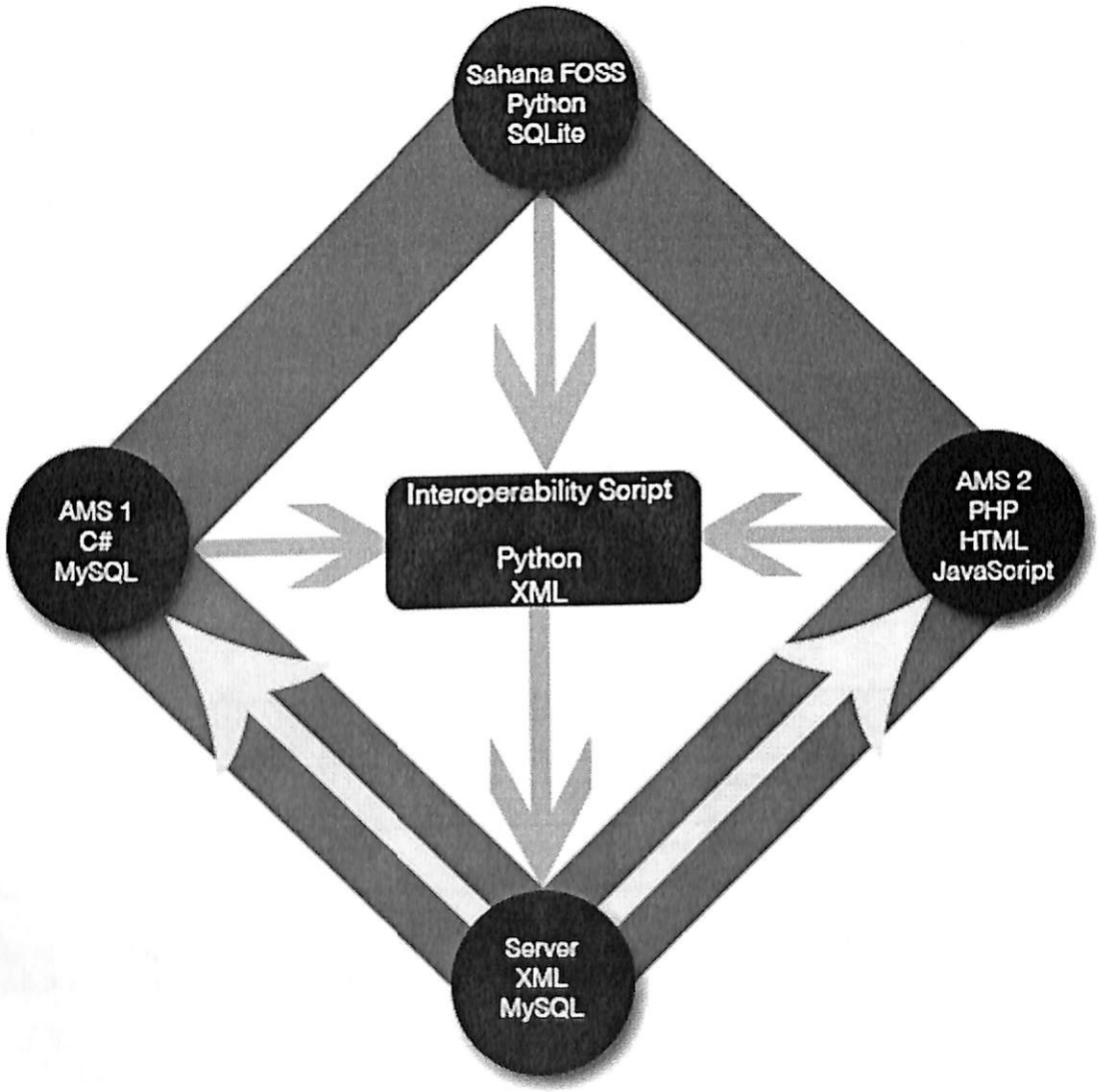
Recovery: The development, coordination, and execution of service- and site-restoration plans; the reconstitution of government operations and services; individual, private-sector, nongovernmental, and public assistance programs to provide housing and to promote restoration; long-term care and treatment of affected persons; additional measures for social, political, environmental, and economic restoration; evaluation of the incident to identify lessons learned; post incident reporting; and development of initiatives to mitigate the effects of future incidents.

Resources: Personnel and major items of equipment, supplies, and facilities available or potentially available for assignment to incident operations and for which status is maintained. Resources are described by kind and type and may be used in operational support or supervisory capacities at an incident or at an Emergency Operations Center.

Response: Activities that address the short-term, direct effects of an incident. Response includes immediate actions to save lives, protect property, and meet basic human needs. Response also includes the execution of emergency operations plans and of mitigation activities designed to limit the loss of life, personal injury, property damage, and other unfavorable outcomes. As indicated by the situation, response activities include applying intelligence and other information to lessen the effects or consequences of an incident; increased security operations; continuing investigations into nature and source of the threat; ongoing public health and agricultural surveillance and testing processes; immunizations, isolation, or quarantine; and specific law enforcement operations aimed at preempting, interdicting, or disrupting illegal activity, and apprehending actual perpetrators and bringing them to justice.

## 4. RESEARCH DESIGN AND METHOD

### 4.1 Conceptual Framework



### 4.2 Methodology

a. Research on CAP Messaging, Disaster and Alert Management Systems
b. Creation of separate Alert Management Systems
   i. AMS 1 will allow CAP creation and updates, view existing alerts and mapping using C# and Python.
   ii. AMS 2 will display affected areas on a web browser using the Google Maps API, HTML, JavaScript and PHP.
c. Enabling of experimental CAP module on Sahana
d. Sahana, AMS 1 and AMS 2 will be linked through a daemon script using Python. Alert messages is received via XML and written on separate databases.
e. Information exchange is facilitated with the use of a UUID across all databases to discourage redundancies.

## 5. RESULTS AND DISCUSSION

The first approach to solve interoperability issues is to first introduce a common ontology for the databases. This is to ensure that there would be no ambiguity with terms, especially for those databases which have compounded entries that are supposed to be separated. Additional information can also be available that cannot fall into any of the categories, so this has to be addressed as well.

| SAME/EAS/FEMA/UN-OCHA | CAP |
|---|---|
| One alert, one info | One alert, multiple infos |
| Geocode | Multiple geocode values |
| Public | Scope |
| Alert | Message Type |
| Active | Status |
| No categories | Multiple categories |
| Victim | Persons Affected |
| Event | Occurrence |
| | Incident |
| | Emergency |
| | Disaster |

The common ontology for terms and fields must be compared to the alert received by the script; this ensures that the alert is not redundant.

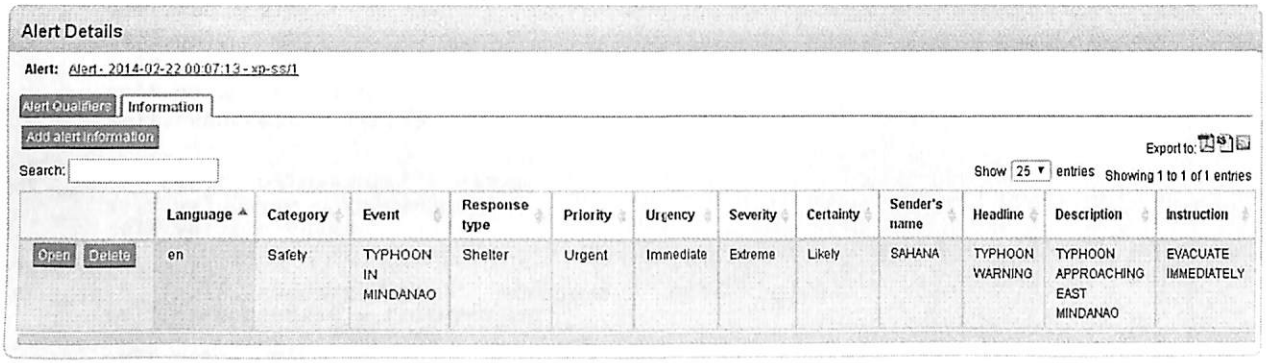



Figure 1. Alert Information fields for a CAP database (Sahana)

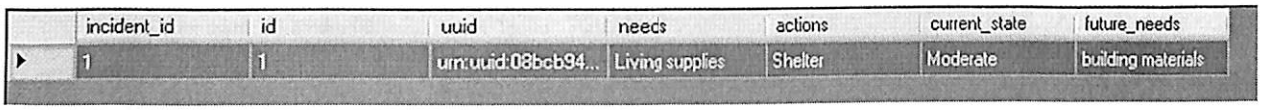



Figure 2. Incident Information fields for W3 database

Some fields of a CAP database are missing in the database of the simulated W3 alert system, and vice versa. Extra fields in the latter system (Figure 2), are equated to nothing in a CAP database, and can be altered only by using the specific system. On the other hand, fields lacking for the CAP database, such as Priority, Urgency and Certainty (Figure 1) are given default values when transmitted onto the server from a non-CAP database, and disregarded when the data enters the W3 system.

The CAP class definitions are as follows:

In Python:

```
class Alert():
def __init__(self,capid=0,identifier='',sender='',sent='',status='',msgtype='',
scope='',uuid=''):
        self.capid = capid
        self.identifier = identifier
        self.sender = sender
        self.sent = sent
        self.status = status
        self.msgtype = msgtype
        self.scope = scope
        self.uuid = uuid
        self.infos = list()
class Info():
def __init__(self,infoid=0,category='',event='',urgency='',severity='',certainty='',
response='',sendername='',headline='',description='',instruction='',web='',uuid=''):
        self.infoid = infoid
        self.category = category
        self.event = event
        self.urgency = urgency
        self.severity = severity
        self.certainty = certainty
        self.response = response
       self.sendername = sendername
        self.headline = headline
```