7. APPENDIX - I

APPENDIX I: VISUAL INFORMATION MODELLER

1. VISUAL INFORMATION MODELLER

During this course of research, the Thing architectural model was developed and a virtual emulated prototype was developed to verify the CoAP communication with OR3C extensions. A need was felt to see the behavioural model of the application with multiple connected devices. In this regard a windows simulation modeller was developed in which the People, Process and Things elements of the PPT model could be modelled and structured with the devices function block model. In this appendix, the screenshots of the visual information modeller are shown. This tool was quickly developed with the help of a home-grown common tools framework. The tool allows the scenarios such as

1) Setting up the facility map or the process diagram with different Thing architectural devices
2) Setting up concerned people (occupants), their hierarchy and the governance agencies including law enforcement , first responders and emergency medical services
3) Setting up processes i.e. Rules, Verification Procedures and Measurement Procedures as developed in the information model.
4) Setting up the Tags and Instruments for safety management and configuring their Block information.
5) Simulate conditions i.e. Notification of Alarm and Alert Conditions to concerned people and to the Law Enforcement agencies
6) Simulate conditions i.e. Correlation of Alarms or Events between two or more entities and initiate actions including notifications and Verification or measurement procedures in aid of the corresponding occupant assigned.

Correlation algorithms are a natural progression to this research to develop pro-active safety through Leading and Lagging indicators. This research has given openness to communication between systems and opened a path to actively develop algorithms to trigger Lead/Lag indicators.

2. TANK SAFETY MODEL

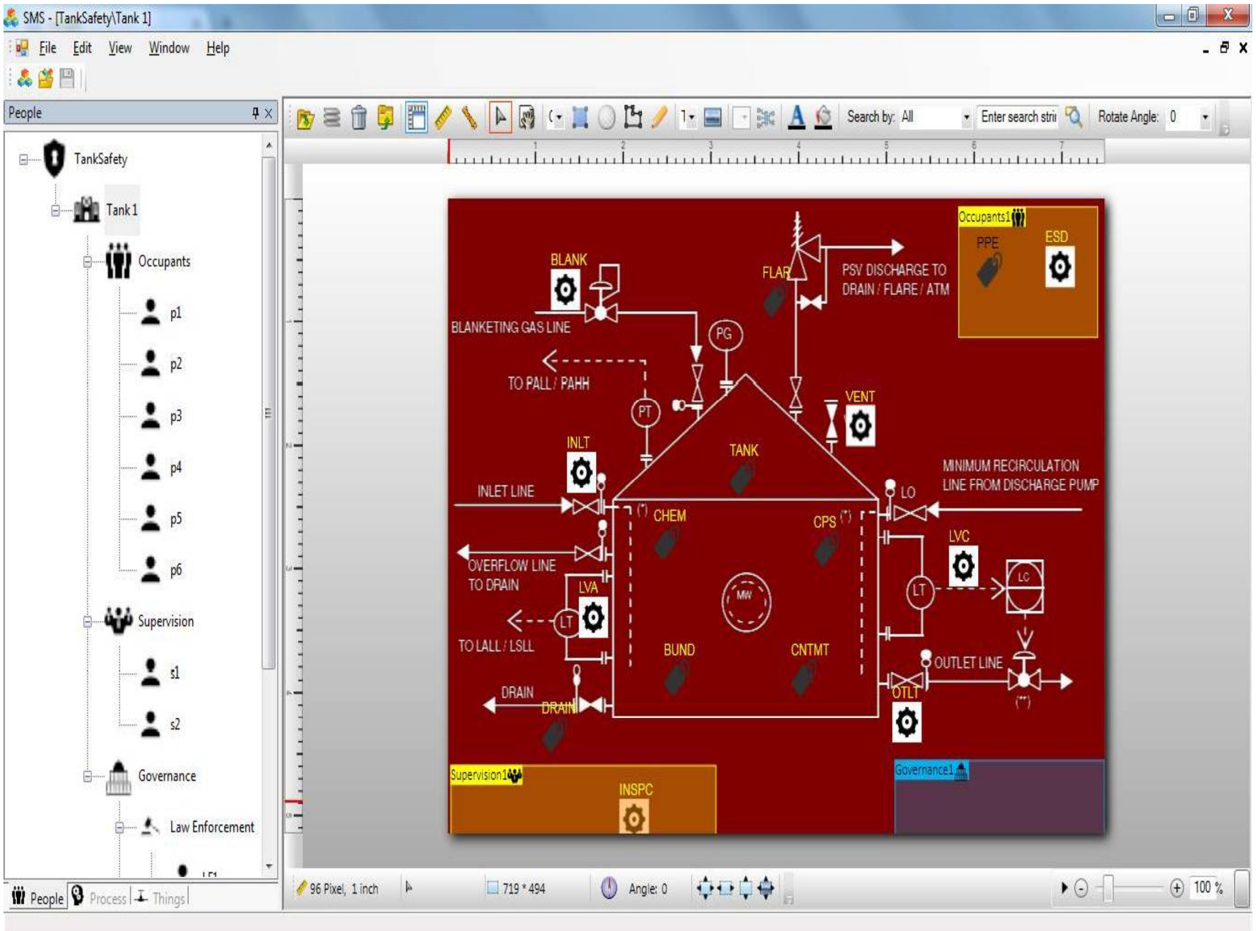

FIGURE 14 TANK SAFETY MODEL

1) Setup different elements of the Tank Safety.
2) Tags and Instruments are modelled concerning different elements of the storage tank.
3) Instruments are natural extension to process automation devices i.e. Level transmitters, pressure gauges or pressure transmitters or valves.
4) Occupants i.e. workers concerned with Tank maintenance, and responsible supervisors are setup.
5) Concerned Law Enforcement , EMS & First response are also setup.
6) Smart Tags like Cathodic Protection System, or stored chemical identifiers or information about BUND and CONTAINMENT are shown.

3. E.G. STORED CHEMICAL TAG IDENTIFIER

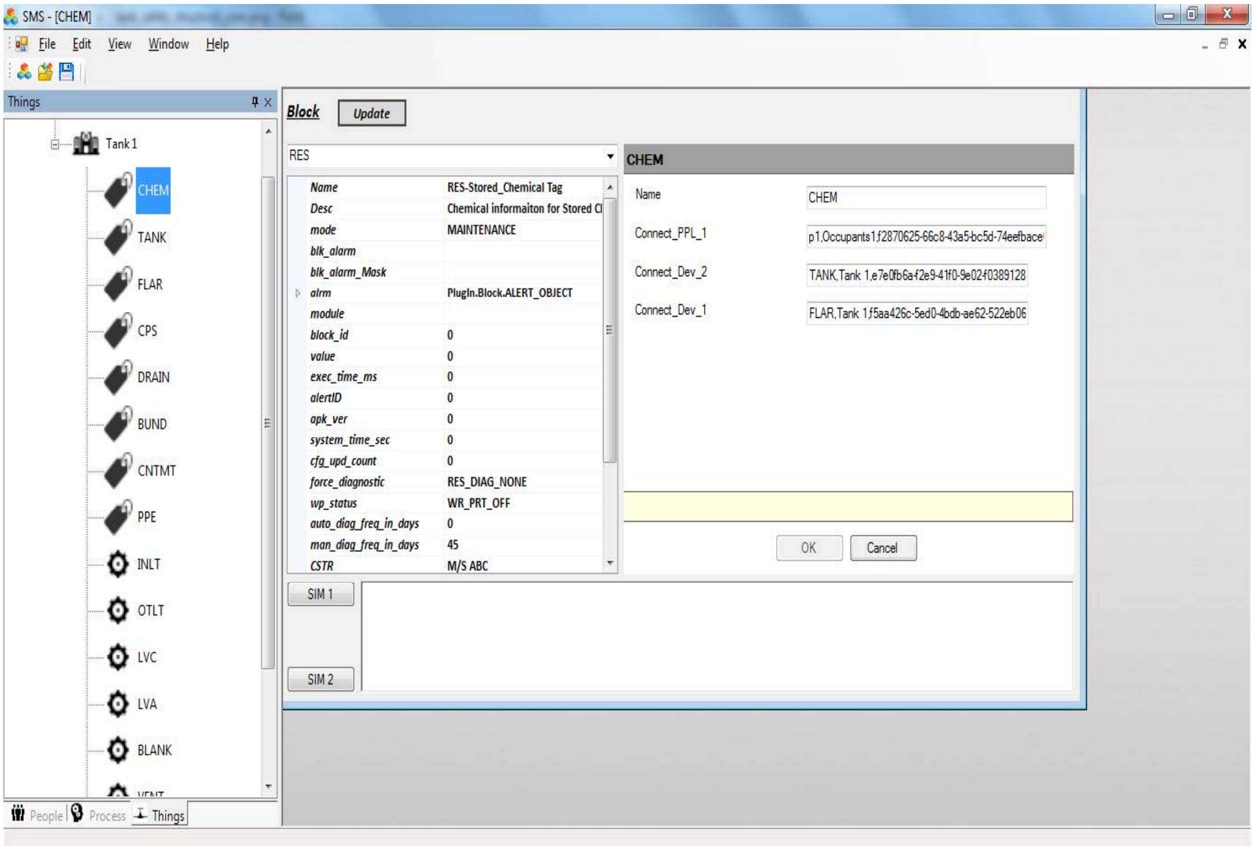

FIGURE 15 BLOCK INFORMATION MODEL

1) Stored chemical identifier Tag is seen in the Things Tab
2) Detailed parametric Block definition of Smart Tag is setup to include details from Manufacturers, to assemblers to detail description of the entity.
3) The info block contains specific properties related to chemical properties including corrosiveness, Permissible exposure level etc.
4) Connection to corresponding Devices as the TANK or the FLAR is configured as shown. Any issues with compatibility between TANK material and CHEM tag could flag up discrepancy Alarms.
5) Person responsible for Chemical storage and management is configured as an association.

4. SIMULATION 1

DISPATCH OF ERRORS TO OCCUPANTS, SUPERVISORS AND GOVERNMENT AGENCIES

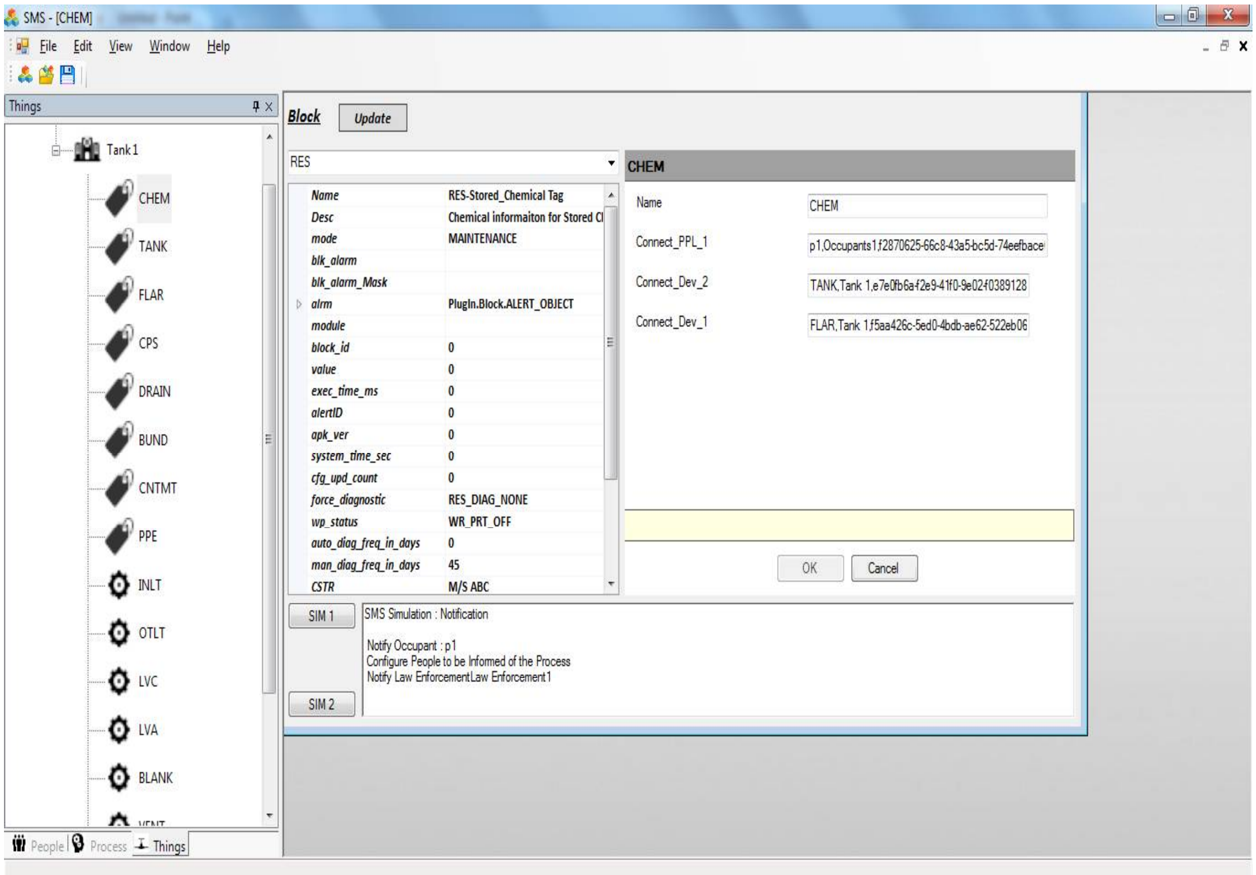

FIGURE 16 SIMULATION 1

1) On simulating SIM1 the notification movement is shown as per the configurations setup.
2) Existing Alarm reporting mechanisms to governments has been self reported and information reported including near misses are less frequent.
3) An automated notification mechanism helps governance to be aware of near misses.
4) Alarm messages include the Block Alarm notification.

Notes:

1) Further simulation through behavioural modelling is possible to see the benefits of notifying supervision / governance to taking corrective actions including near misses.
2) In safety management practice, observed errors are due to Lack of proof testing and disordered management of change and insufficient audits.

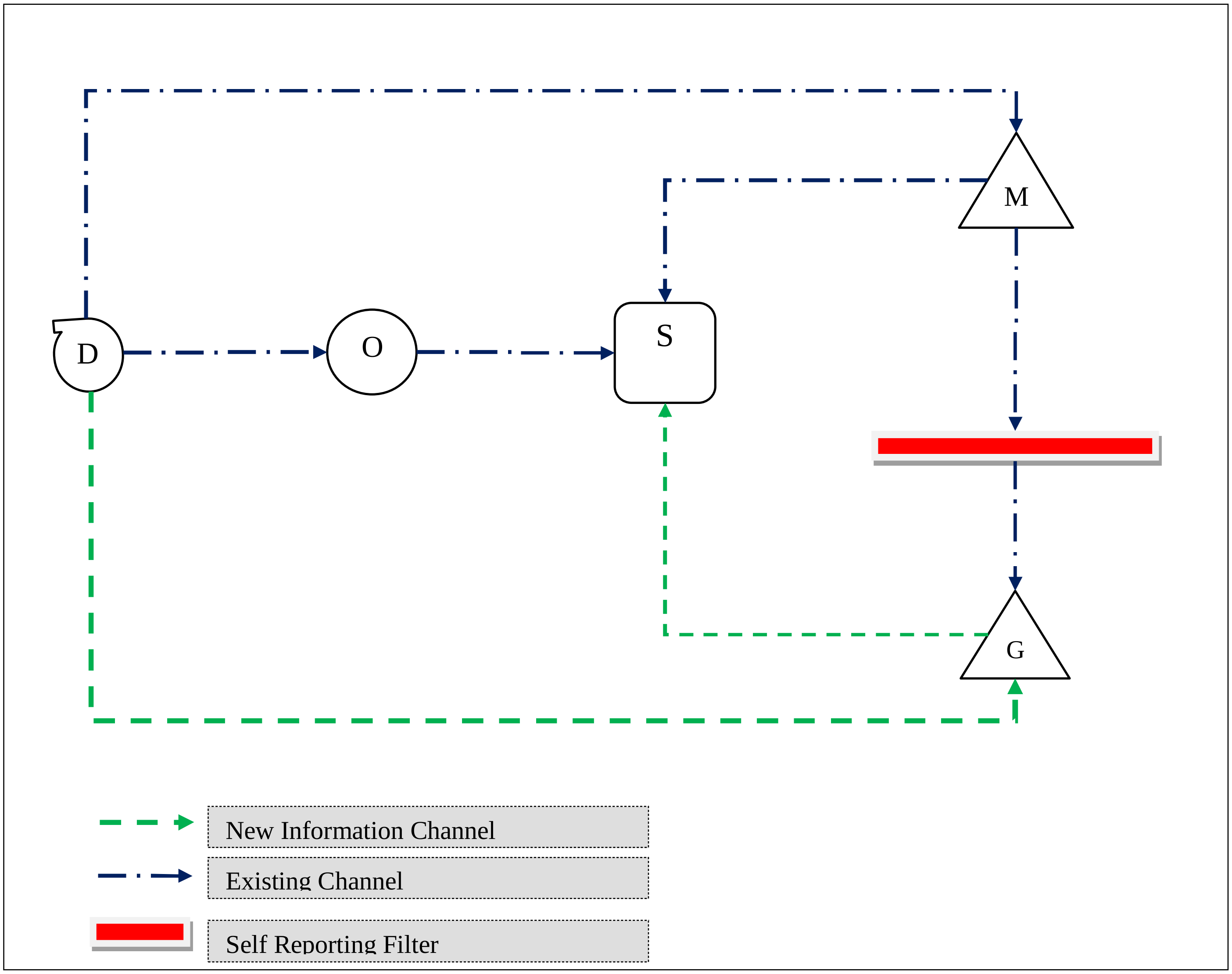

FIGURE 17 SIM1: NEW MODEL FOR INFORMATION REPORTING

5. SIMULATION 2 – LEAD / LAG INDICATORS

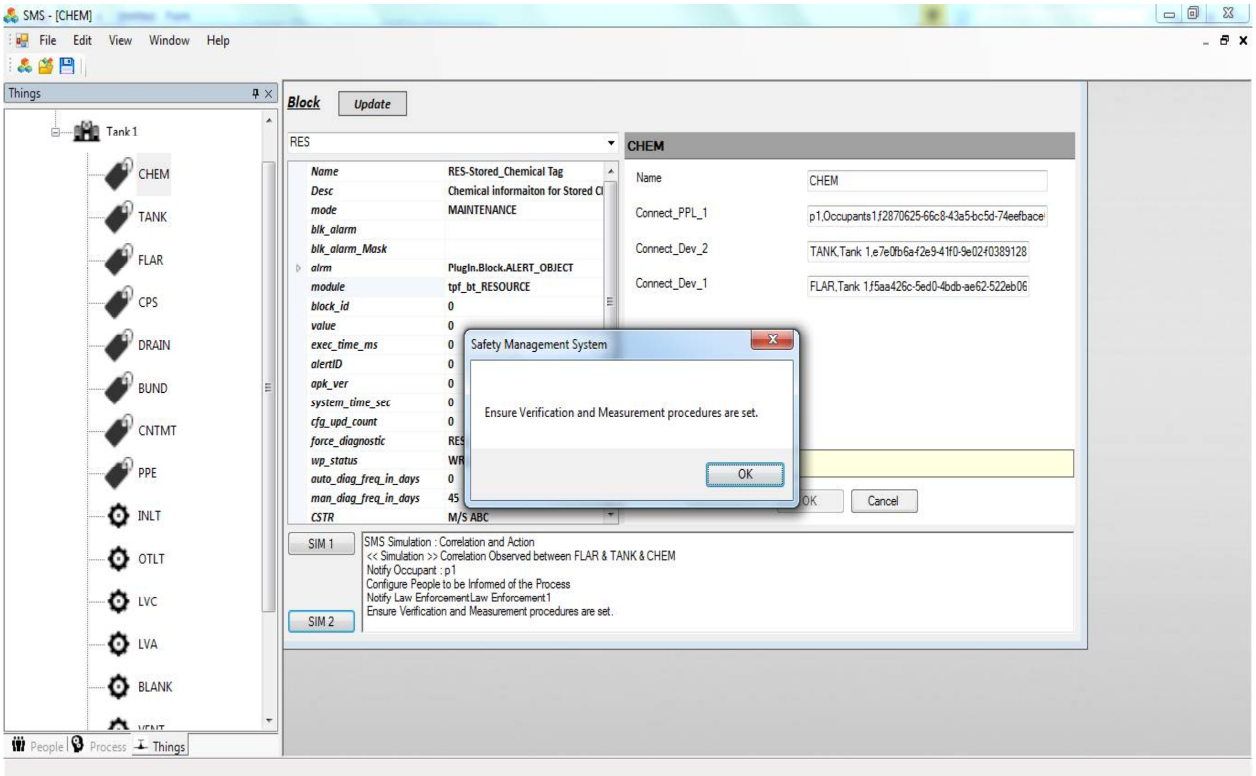

FIGURE 18 CORRELATION OF CONNECTED DEVICES TO IDENTIFY LEAD/LAG INDICATORS

1) Correlation between connected devices i.e. TANK material and FLAR and the CHEMICAL can be modelled with standard block parameters
   i.e. blk_alarm
   Value
   Operating Mode
   PT_DATE
2) Indications of variations lead to activation of Correlation Alarms which are notified as in Simulation 1.
3) An additional step to inform the occupant about the VERIFICATION Procedure or procedural MEASUREMENTs is given to occupant as shown.

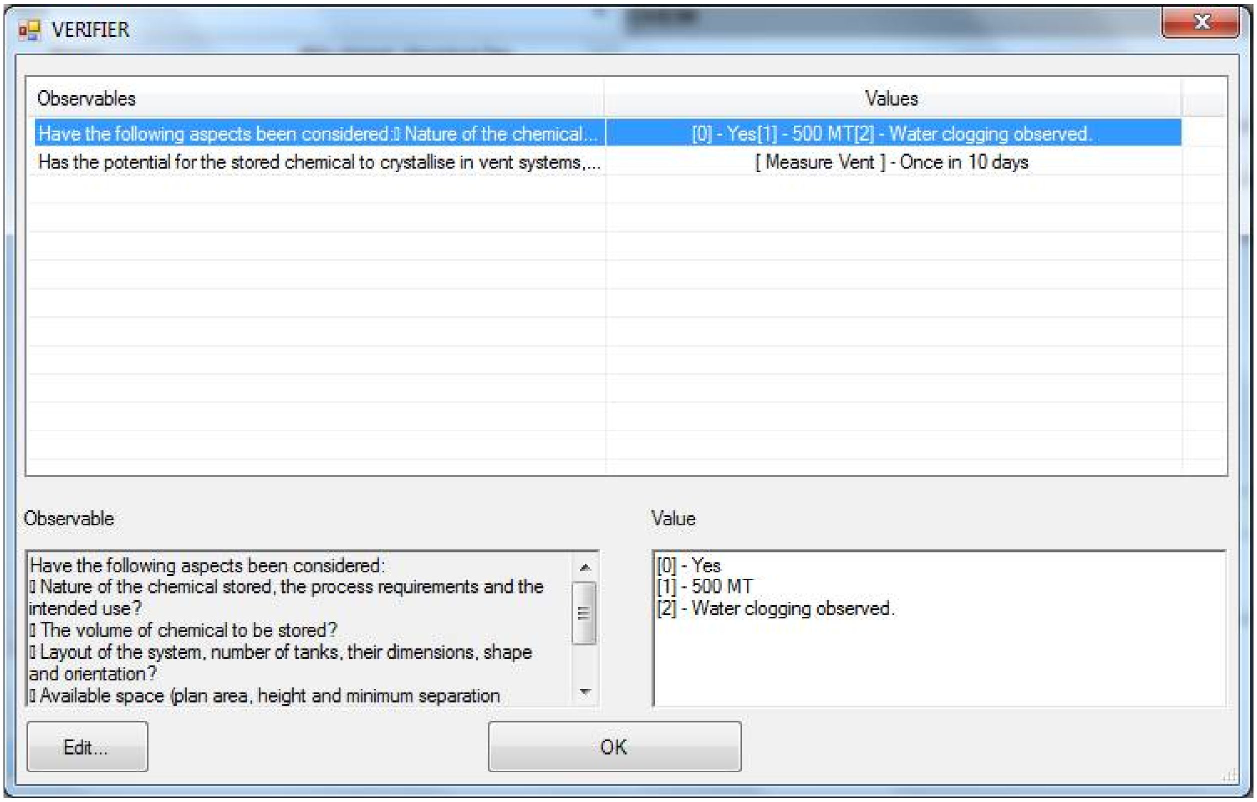

FIGURE 19 VERIFIER MODEL

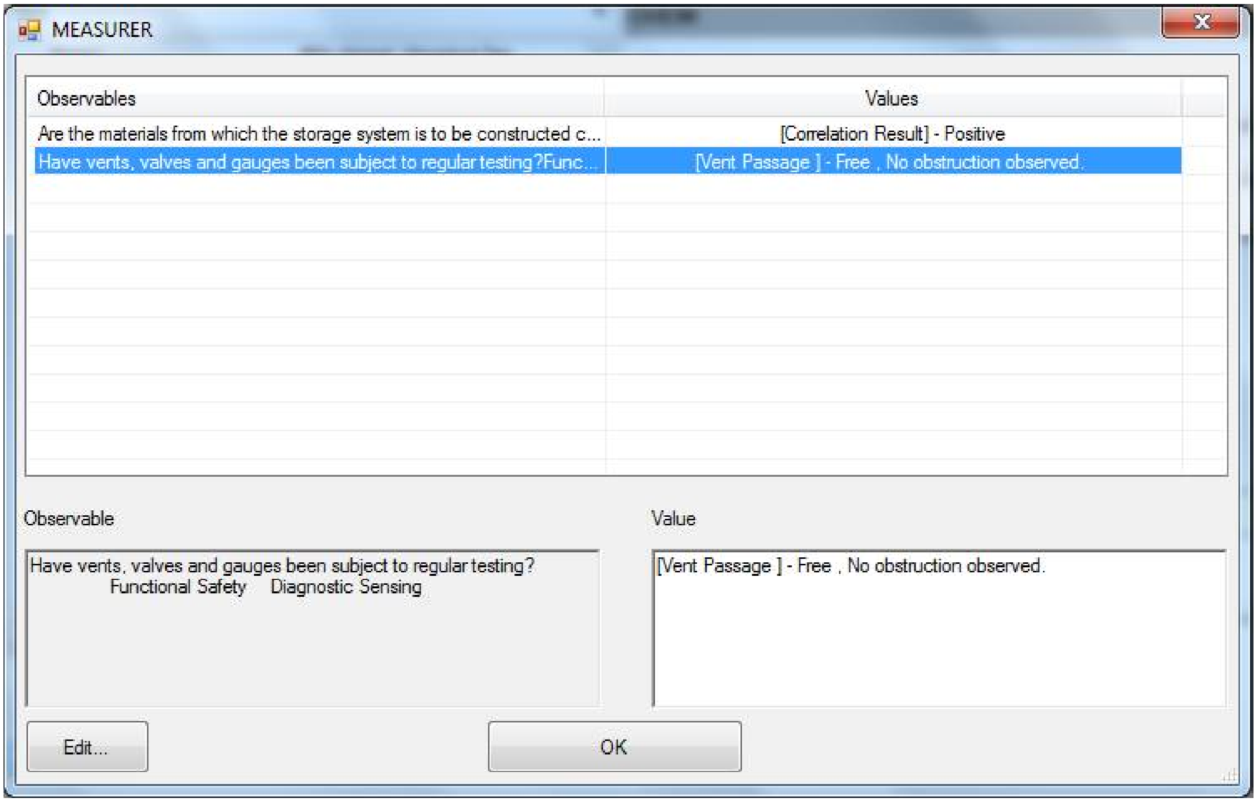

FIGURE 20 MEASURER MODEL

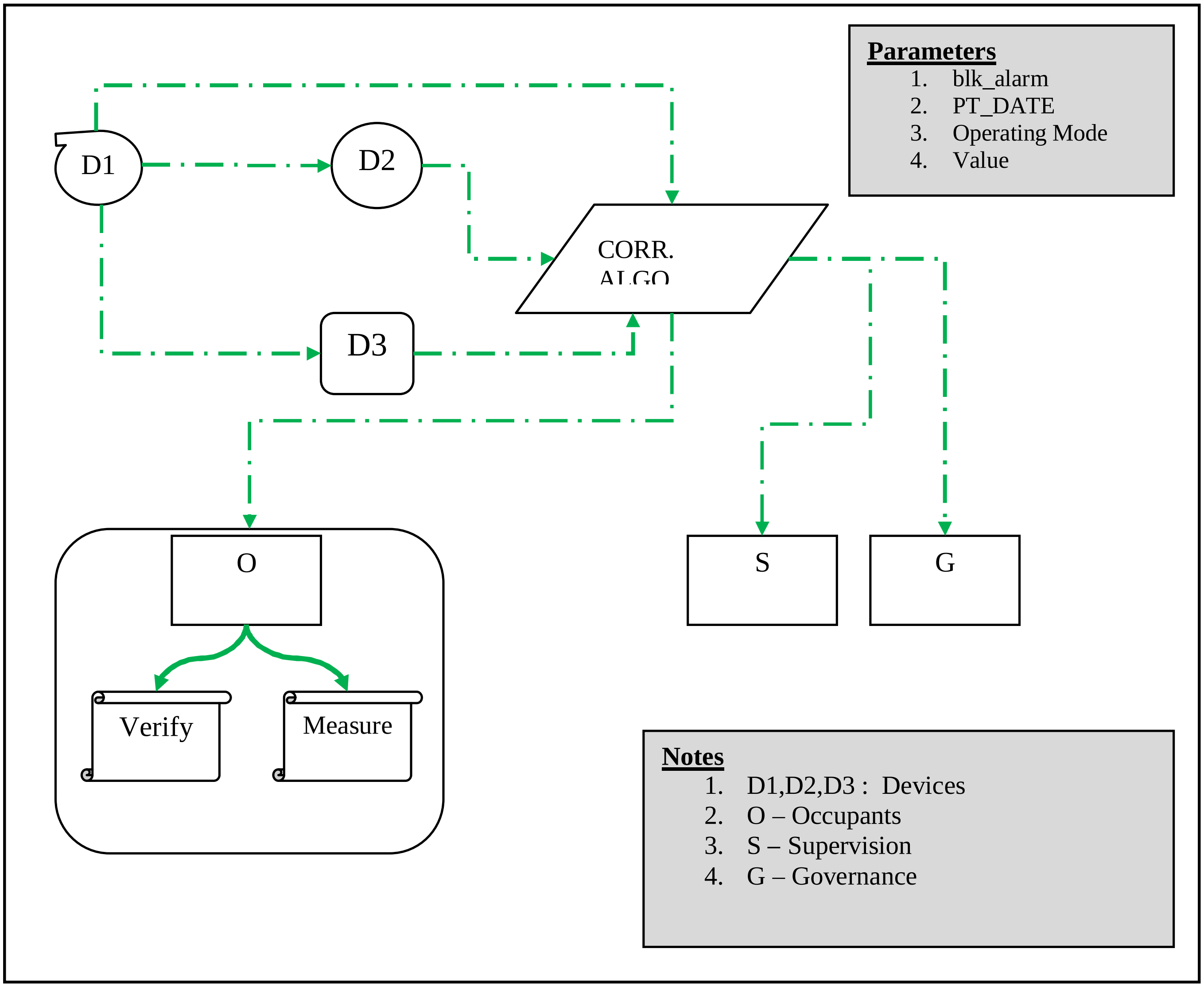

FIGURE 21 SIM2: LEAD / LAG INDICATION

8. APPENDIX - II

APPENDIX II: RECOMMENDATIONS FOR LTE COMMUNICATIONS

1. LTE COMMUNICATIONS BASICS

Traditionally, operators have built multiple networks to provide multiple services to customers such as fixed telephone networks, cable TV networks, cellular telephone networks and data networks. The Next Generation Network (NGN) provides all of these functions using a flat all-IP core that interconnects multiple access technologies and provides a consistent and reliable user-experience regardless of the access method. The NGN core will provide Quality of Service (QoS) support and a wide variety of applications and services. The NGN access network will provide mobility and routing management and ensure that the core sees the mobile networks simply as another IP network. Mobile handover between access types will be seamless as the IP access network controls security, authentication, and billing for the multiple access technologies. LTE is the first technology designed explicitly for the NGN and is set to become the de-facto NGN mobile access network standard. It takes advantage of the NGN's capabilities to provide an always-on mobile data experience comparable to wired networks.

2. LTE Network Components and Functions

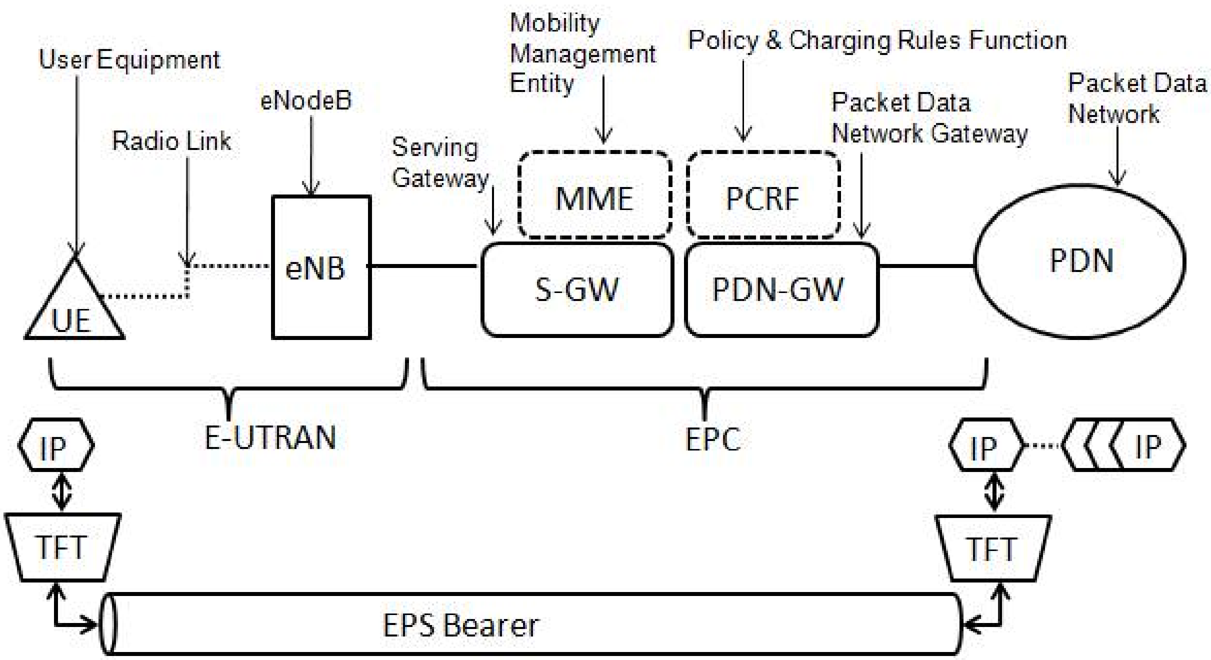

FIGURE 22 LTE NETWORK COMPONENTS

UE (User Equipment)

3. Access device for user.
4. Provides measurements that indicate channel conditions to the network.

eNB (Enhanced Node B)

- Hosts the PHYsical (PHY), Medium Access Control(MAC), Radio Link Control (RLC), and Packet Data Convergence Protocol (PDCP) layers.
- Controls user-plane header-compression and encryption.
- Provides Radio Resource Control (RRC) functionality for the control plane.
- Functions include radio resource management, admission control, scheduling, enforcement of negotiated uplink QoS, cell information broadcast, ciphering/deciphering of user and control plane data, and compression and decompression of downlink and uplink user-plane packet headers.

PDN Gateway (P-GW)

- Provides connectivity between the UE and external packet data networks (PDNs) by being the point of exit and entry for UE traffic (A UE may have simultaneous connectivity with more than one P-GW for accessing multiple PDNs).

- Performs policy enforcement, packet filtering for each user, charging support, lawful Interception, and packet screening.
- Acts as the anchor for mobility between 3GPP and non-3GPP technologies such as WiMAX and 3GPP2 (CDMA 1X and EvDO).

MME (Mobility Management Entity)

- Acts as the key control node for the LTE network.
- Responsible for idle mode UE tracking and paging procedure including retransmissions.
- Controls bearer activation/deactivation process.
- Chooses the Serving Gateway (S-GW) for a UE at initial attachment and at the time of intra-LTE handover.
- Authenticates the user by interacting with the Home Subscriber Server (HSS) [Not shown in diagram].
- Serves as the termination point for the Non-Access Stratum (NAS) signaling. NAS signaling is responsible for generation and allocation of temporary identities to UEs and checks the authorization of the UE to camp on the system.
- Serves as the termination point for ciphering and integrity protection for NAS signaling.
- Handles security key management.
- Provides control plane function for mobility between LTE and other access networks.

Serving Gateway (S-GW)

- Routes and forwards user data packets.
- Acts as the mobility anchor for the user plane during inter-eNB handovers and as the anchor for mobility between LTE and other 3GPP technologies.
- Terminates the downlink data path for idle state UEs and triggers paging when DL data arrives for the UE.
- Manages and stores UE contexts, e.g. parameters of the IP bearer service and network internal routing information.

3. LTE FRAME STRUCTURE AND COMMUNICATION CHANNEL

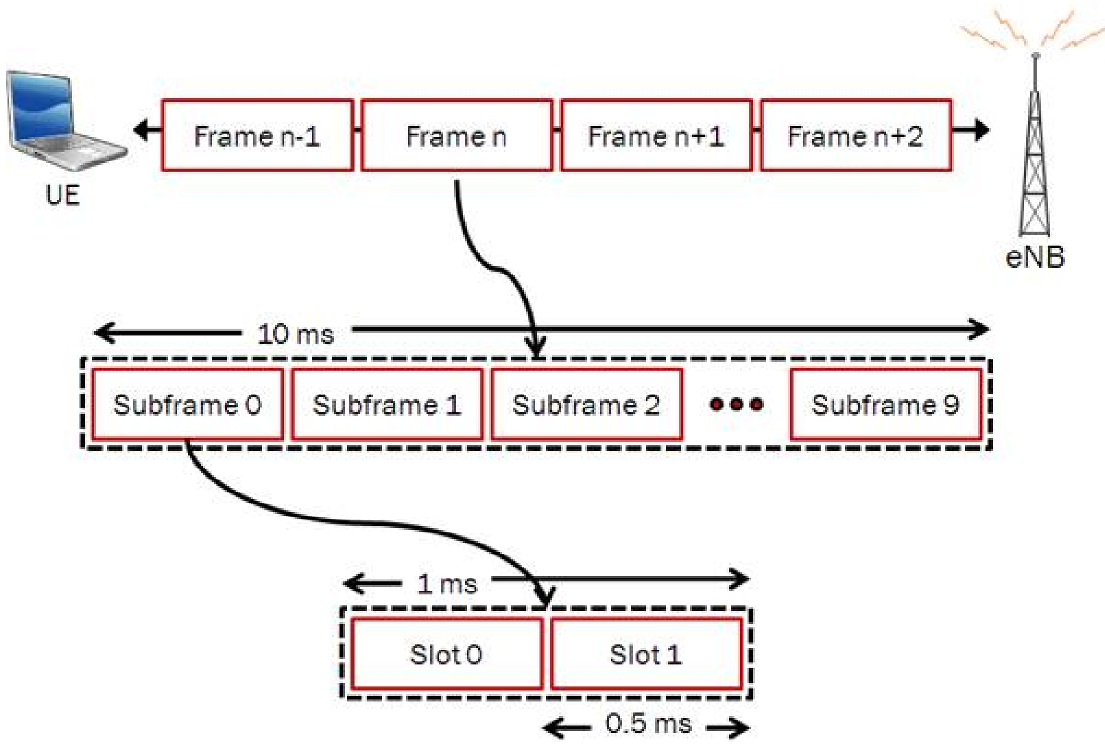

FIGURE 23 LTE FRAME STRUCTURE

The duration of one LTE radio frame is 10 ms. One frame is divided into 10 sub frames of 1 ms each, and each sub frame is divided into two slots of 0.5 ms each. Each slot contains either six or seven OFDM symbols, depending on the Cyclic Prefix (CP) length. The smallest modulation structure in LTE is the Resource Element. A Resource Element is one 15 kHz subcarrier by one symbol. Resource Elements aggregate into Resource Blocks. A Resource Block has dimensions of subcarriers by symbols. Twelve consecutive subcarriers in the frequency domain and six or seven symbols in the time domain form each Resource Block.

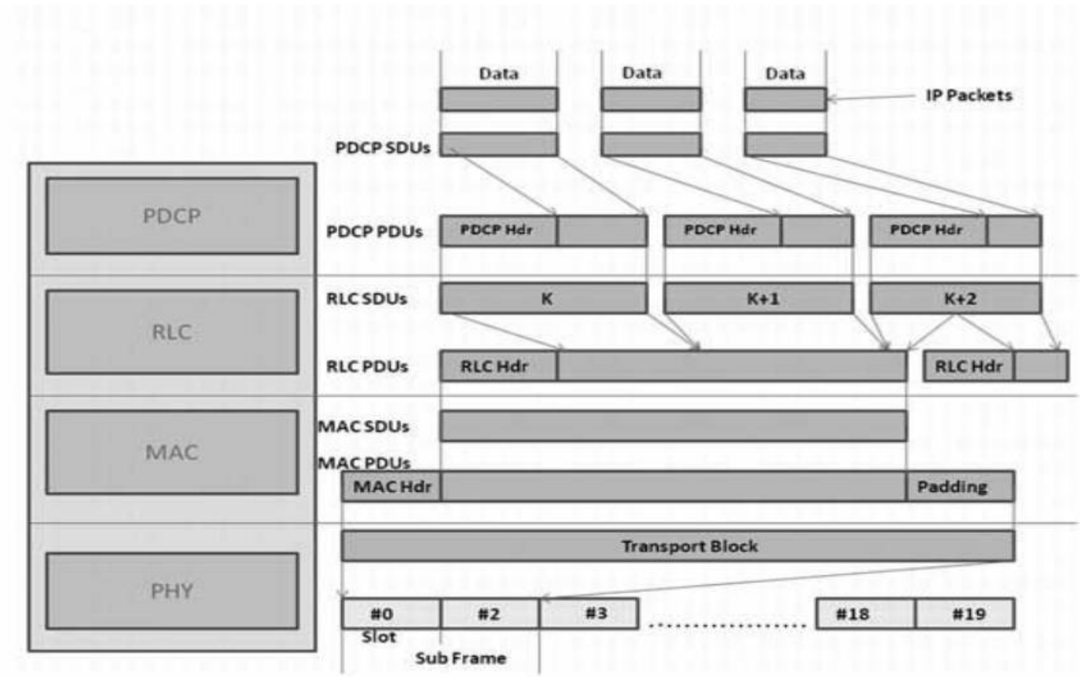

FIGURE 24 LTE PROTOCOL STACK LAYER

All LTE Communications happens through IP communications structure through the protocol stack layers i.e. PDCP (**Packet Data Convergence Control**), RLC(**Radio Link Control**) , MAC and PHY.

The following physical channels are used for the communications in the downlink.

- ✓ **Physical Downlink Shared Channel (PDSCH)**
- ✓ **Physical Broadcast Channel (PBCH)**
- ✓ **Physical Control Format Indicator Channel (PCFICH)**
- ✓ **Physical Downlink Control Channel (PDCCH)**
- ✓ **Physical Multicast Channel (PMCH)**
- ✓ **Physical Hybrid ARQ Indicator Channel (PHICH)**
- ✓ **Paging Control Channel (PCCH)**

The following physical channels are used in the communications for the uplink.

- ✓ **Physical Uplink Control Channel (PUCCH)**
- ✓ **Physical Uplink Shared Channel (PUSCH)**
- ✓ **Physical Random Access Channel (PRACH)**

Every UE utilizes the PRACH for acquiring dedicated channels for transmission and reception and establishing communications. This random access process for acquiring channels utilizes Slotted ALOHA techniques with carrier sense multiple access schemes.

Similarly Inward messages and calls are informed using the PDCCH and PDSCH and then the LTE implements IP bearers for connecting and completing CALLS or Messages using the IP Multimedia Sub System or IMS specifications.

4. RECOMMENDATIONS FOR LTE FOR DISASTER MANAGEMENT

Recommendation 1

Based on our research and CoAP transport we could verify that safety information can be sufficiently communicated over CoAP systems and critical alert information contain parameters like

- Device Identifier – Available as the unique IPv6 MAC from LTE
- Block ID - 2 Byte standard definition Information
- Block Alarm – 2 Byte or 16 bit representation
- Value – 4 Byte or Single representation
- Operating Mode – 1 Byte Standard Enumeration
- Proof Test Dates – 4 Bytes or Epoch Time

All of this information can be sufficiently represented in short frames and as Becker et al have earlier proposed to transmit CoAP over SMS.
In an LTE implementation SMS transmission reception is as costly as acquiring resources for a CALL connection.
In view of this the following recommendation is made

Utilize Channel access scheme PRACH to transmit additional bytes of Alert data from Fixed Safety Related instruments data.

Recommendation 2

Similar to transmission of Alerts the PDCCH carries information regarding who has to receive CALL or SMS data and the UE has to acquire resources to establish connection.

Again as we see above the Safety related Alert information to be communicated is of less size and can be accommodated in the PDCCH frame.

Similar extension has been made in the Japanese implementation of LTE for ETWS (Earthquake and Tsunami Warning System).

The LTE UE's capable of ETWS, receives information from the e-NodeB from the standard PDCCH frame on the Paging Control Channel (PCCH) frame about additional information available on ETWS.

This implementation thus notifies all the ETWS capable UE's about a disaster occurring in every PCCH cycle which happens every 320 ms (configurable up-to 2.56s).

In case of LTE for Disaster management the same ETWS implementation can be adapted and enhanced.

A major difference that has to be brought is, the existing ETWS design is Broadcast system and in the case of Disaster Management it has to be enhanced to support Multicast communications.

Utilize PCCH channels to transmit Alarms to concerned devices and people using a Multicast mechanism.

Recommendation 3

The LTE connection establishment is through a PRACH uplink channel which is Random in nature and uses Slotted ALOHA carrier sense multiple access techniques to acquire channels. This is a lossy approach and is prone to stress on the battery life of devices.

In the case of Smart Tags which could be battery powered and a passive device, the Tags life reduces because of channel access mechanisms and periodicity of PING responses.

In the Machine to Machine communication context with battery operated TAG devices, possibilities of Fixed Slot communications / Static resource allocation for such tags have to be developed.

Develop schemes for Static Resource Allocation for Battery powered devices.