Joint Defra/EA Flood and Coastal Erosion Risk Management R&D Programme

Improved dissemination of flood warnings - Phase 2

R&D Technical Report FD2209/TR



Environment Agency

defra
Department for Environment Food and Rural Affairs

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R&D Technical Report FD2209/TR

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Statement of use
The report presents technical information and research findings from R&D Project FD2209.
It is recommended that the report is used in 2 main areas:

- Enhancing the understanding of public warning and information dissemination for the Environment Agency, its research programs and its Multi Media Warning Dissemination Service. (This is now named Flood Line Direct, however MMWDS is still used in this document for consistency)
- Recommendations to the Cabinet Office from the National Steering Committee for Warning and Informing the Public and other similarly interested bodies.

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Executive Summary

Part 1 of this programme, carried out under Project FD2202, had three work packages: WP1 – Technology comparison, WP2 – Requirements analysis, WP3 – International perspective.

These identified channels as either in use, under trial elsewhere or are unsuitable in other ways. The recommendation to the Environment Agency (EA) was to use mature technologies in a novel arrangement to provide a community based flood warning and response system.

This report covers Phase 2 of the programme, the proof of principal system that was successfully demonstrated March 2004 at Malvern to the Project Board. This report re-presents some of the work from Phase 1 to allow it to be read in isolation by a reader with no prior knowledge of the programme.

The approach tested should have a positive impact on community response to flood alerts as well as improving the warning service in all areas in comparison to the Automated Voice Messaging (AVM) system. The demonstration showed the approach is practicable.

A summary of the advantages include:

- Pervasive alerting with multiple presentation device types,
- Low running costs compared to AVM etc.,
- Dissemination rate would be close to that of purely broadcast systems,
- Digital messaging to allow any content,
- Message targeting could be multicast and/or unicast,
- Messages could contain highly localised information such as who in your street has spare sand bags/needs help etc.,
- Receipting to include assistance requests and offers of assistance,
- Receipting information would be available per individual,
- Receipting delivered as summaries reducing incoming message tally to EA, and
- Improved scalability
- Improved utilisation of future increase in the abundance of communication channels

The demonstration system showed the feasibility of self-organised community-based response, with the following features:

- two-way communications being put in place
- has an instant messaging chat facility
- the flood warden can also send messages to all the devices - multicast messaging
- the warden would have summary lists of those who had acknowledged warnings, those who had asked for assistance and those who had not yet responded

- a number of specific application types for aiding community response have also been identified.

In order to facilitate the above in a way that is appropriately scalable, a detailed warning process and supporting framework was implemented for the demonstration system. This represents a significant step forward for the programme and was designed to be reused in future work. However, such detailed design issues are beyond the scope of this report.

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List of Abbreviations

AVM	Automated Voice Messaging
BER	Bit Error Rate
CAP	Common Alert Protocol
DAB	Digital Audio Broadcast
DECT	Digital Enhance Cordless Telecommunications
DPRS	DECT (Digital Enhanced Cordless Telecommunications) Packet Radio Service
EA	Environment Agency
EIA	Environmental Information and Alerts
GDIN	The Global Disaster Information Network
GIS	Geographic Information System
GML	Geographic Mark-up Language
GUI	Graphical User Interface
HSE	Health, Safety and Environment
IEEE	Institute of Electrical and Electronic Engineers
ICT	Information and Communication Technology
MMWDS	Multi-Media Warning Dissemination System - now known as Flood Line Direct
NSC WIP	National Steering Committee for Warning and informing the Public
PA	Public Address
PPW	Public Partnership for Warning
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RDS	Radio Data System
SLA	Service Level Agreement
SMCR	Sender, Message Channel, Receiver
SMS	Simple Messaging Service
WP	Work Package

Glossary

Asynchronous
Asynchronous communications are achieved without both parties participating at the same time. For example, a message on an answering machine is asynchronous, from a human perspective.

This is true for many forms of modern communications, they are asynchronous from a human perspective (news groups, SMS, email etc.).

Examples of asynchronous *channels* would be print, and radio broadcasts. See also synchronous below.

Bandwidth
Bandwidth describes the amount of frequency used by an electromagnetic signal. Can be used as part of QoS measures.
See also data rate.

BER
Acronym for Bit Error Rate. This refers to how often one bit of a digital communications channel will be interpreted wrongly against those that will be received correctly as a statistical probability ratio. Error correction technologies are designed to reduce the impact of this and can appear to reduce BER but this is usually at the expense of 'useful' data rate (some bits are being used for correction rather than data). Can be used as a QoS measure.
See also data rate.

Broadcast
The type of multiplicity where one sender can send a message to many receivers at once with no additional effort involved per recipient.

See also multicast, unicast, multi-unicast, multiplicity and fusion-cast.

Data Rate
A quantitative measure of bandwidth commonly used in digital communications. It is usually measured in bits per second (a bit being an encoded 1 or 0).
See also bandwidth.

Duplex
Duplex communications are ones where both parties are able to send and receive at the same time, hence they are always synchronous.

See also half duplex, simplex and synchronous.

Fusion-cast
Relates to agents that are combining several channels into one more useful channel. These agents are usually implemented in software, but the mass media for example provides this function with different emphasis for different areas of coverage.

See also broadcast, unicast, multicast, multi-unicast, and multiplicity.

Half-duplex
Half-duplex communications are ones that are synchronous where only one party can transmit at any one time.

See also duplex, simplex and synchronous.

Multicast
Esp. Internet, a form of multiplicity where highways are set up to reduce the amount of packets sent. Special nodes act as broadcasters for otherwise unicast links.

See also broadcast, unicast, multi-unicast, multiplicity and fusion-cast.

Multi-unicast
Several parallel unicast channels esp. across the Internet.

See also broadcast, unicast, multicast, multiplicity and fusion-cast.

Multiplicity
Refers to the numbers involved in a communications link. For example one broadcast sender to many broadcast receivers.

See also broadcast, multicast, unicast, multi-unicast and fusion-cast.

PSTN
Acronym for Public Switched Telephone Network. This term refers to all intervening equipment that joins two members of the public when they make a telephone call.

Pull
Pulled communication is that which the receiver has sought for. The main message sender is only communicating on request. Usually the *first* message sent is a small/short request followed by *main* message/s sent as a result. An example is someone seeking information from Teletext.

See also push and user triggered push.

Push
Pushed communication is that which the receiver has *not* sought for. The *only* message is that from the sender; a siren is an example.

See also pull and user triggered push.

User Triggered Push
A push of information, the sending of which has been defined by the recipient (rather than simply by the position of their dwelling).

Simple pushes have no precursor message. User triggered pushes have an initial request message from the recipient then a main message.

Initiation may be complex and can even be a dialogue rather than a single message. The recipient does not know when the main message (such as a warning) will be pushed. Usually there will be a significant delay between the initiating message and the push.

Different channels are sometimes appropriate for the initial and the main message. For example you initially use an Internet form and receive the pushed information via SMS and e-mail.

See also pull and push

QoS
Acronym for Quality of Service. This term refers to the measurement of performance of a service, such as a communications service or link.

See also data rate.

Simplex
Simplex communications are ones where only one party can send messages and the other party receives; usually, but not necessarily, broadcast.

See also half duplex and simplex.

Synchronous
Synchronous communications are achieved with both parties participating at the same time.

Unicast
The type of message multiplicity that refers to a channel with a single sender and a single receiver; the receiver may be able to reply.

See also broadcast, multicast, unicast, multi-unicast and fusion-cast.

1 Introduction

1.1 Purpose

This document details the conception and demonstration of the community centric flood warning and response system, carried out under Project FD2209. It is intended to have two main functions: as a project summary and to provide conclusions and recommendations for future direction. The direction sought is to improve the identified areas of warning services at best value to the EA and to make best use of likely future developments.

This document draws on text and diagrams from Phase 1 of the programme, Project FD2202, as it is anticipated that this document will be most useful if it can be read in isolation.

Please refer to the glossary if you are unfamiliar with any terms.

1.2 Scope

An average of €1.2 billion of damage is done each year to some of the 1.9M households at risk from flooding. Targets have been set from central government to reduce the amount of damage caused by flooding. As well as investing in defences, public education and forecasting etc. a cost-effective way of reducing the damage could be to better inform the public, allowing them to respond accordingly.

The Environment Agency (EA) is the lead organisation for warning the public in England and Wales with regard to flooding.

The warning process can be simplified as follows.

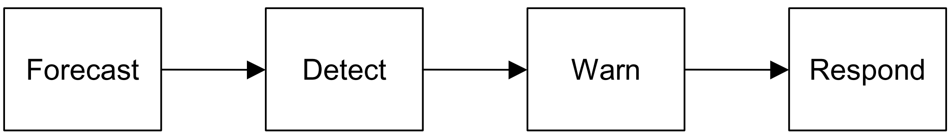

Figure 1.1 Simplified warning process

Any requirement of the final system or a channel trial system should be traceable to the need to inform the public (or other organisations entrusted with their welfare) in order that they can take any necessary actions.

1.3 Approach to work package 4

The programme had three previous work packages: WP1 – Technology comparison, WP2 – Requirements analysis, WP3 – International perspective, all carried out under Project FD2202.

Work Package 4 covers the work under this project, the conception and demonstration of a community based flood warning system. The approach taken to achieve the purpose follows these steps:

- Bring together the channel applicability matrix form, with the aspects of service and requirements in light of international developments.
- Exploit the advantages of heterogeneous channels
- Exploit advantages of hierarchical channels
- Attempt to address the above with a desire to push the use of these channels so they can also improve a communities' response to flood alerts.

1.4 Document structure

Section 2: Project summary:

- This section gives a brief synopsis of Phase 1, its findings and impact.

Section 3: Single channel trial options:

- This section details how the work from Phase 1 was used to identify the option selected for a demonstration system.

Section 4: Proposed demonstration system:

- This section provides the rationale and details of a cutting edge heterogeneous, hierarchical demonstration system, with self-aware community networks.

2 Background – work carried out under Phase 1

2.1 Introduction

This section gives a brief synopsis of Phase 1 of the programme, its findings and impact. Full details of the work carried out under Phase 1 can be found in Technical Report FD2202/TR.

Please refer to the glossary if you are unfamiliar with any terms.

2.2 WP1 Modelling synopsis

The points found to be most salient from WP1 were the communication models, the recipient scenarios and the matrix of applicability.

2.2.1 SMCR Communication model

The most common model for communications is information theory developed by Shannon and Weaver (1949). This model recognises four elements: a **Sender**, who passes a **Message**, through a **Channel**, to a **Receiver**. Those developing technology (e.g. telephony and computer systems) as well as those involved in communication process engineering/management have successfully used this SMCR model.

The simple approach has been adopted as the main means by which communication ideas were presented diagrammatically in the T15 deliverables.

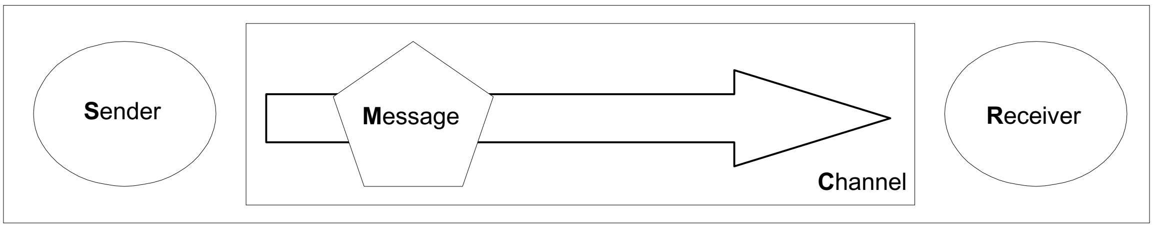

Figure 2.1 The SMRC communication model

2.2.2 Weaknesses of the SMCR model

WP1 identified that although SMCR is simple and easily understood, by itself it does not address all the relevant issues. SMCR leads analysts to assume that the sender and receiver are roughly similar. This leads to an over optimistic view that the recipient will understand the message in the way the sender intended more often than will actually be the case.

The meaning of the message is lost if there is insufficient common understanding between these parties. When the recipient and sender are computer systems for example, such problems should be both easy to discover and address. However, when the recipient and sender are human, receipt of the message alone does not mean that transfer of understanding has occurred, only that a message has been delivered.

The successful transfer of meaning is usually undertaken to have effect on the recipient. This is certainly the case for flood warning, i.e. to take appropriate action for the threat (e.g. protect dwelling, evacuate etc.).

So, how risk is communicated in flood warning can be as least as important as whether communication takes place at all. Weaknesses can be found and resolved using the constructivist model.

2.2.3 Constructivist model

Unlike the SMCR model, the constructivist model (Bennett 1987) takes into account differences between parties. It seeks to find the differences in understanding between the parties, to empathise with both of them, and to evaluate whether the communication is fit for purpose from both viewpoints.

However, given the large matrix of senders, recipients, channels and message types dealt with, it was beyond the scope of the project to perform constructivist analysis. QinetiQ recommends that a future research direction for flood warning could be risk communication, especially in respect to communities with large mixes of cultures and language.

2.2.4 Communication relationships

Messages have two levels, the explicit and the implicit (Bateson 1979). The explicit is the content, the ‘actual’ message. The implicit is related to who the sender is and the relationship between the sender and the recipient. The implicit level greatly effects the interpretation of the explicit level.

In the context of flood warning dissemination this means that channels (or the messages themselves) should make apparent who the sender is, that the communication has a foundation that is credible to the audience and that credibility is always maintained. In particular, communication should be as timely, precise and accurate as possible.

2.2.5 Risk communication

At its most basic, risk communication is the communication of the probability and impact of a possible event.

The implication of sections 2.2.5 to 2.2.13 is that risk communications play a major part of the success of flood warning dissemination, as it will greatly shape the audience response.

Examples of different approaches for describing risk in terms of probability are "One in a hundred years", "One per cent chance this year" and "Will probably occur in your lifetime".

Risk communication is applicable before an event as part of public education; this could be thought of as risk preparation or reduction. It could also be applicable during an event if message content was expressed as a risk. In doing so the maintenance of credibility can be achieved more easily e.g. warning of the *possibility* of further rise or inundation.

Risk communication can also be visual. For example in some states in Australia rings are placed on telephone poles at the high points of previous floods.

In the recommendations section it is noted that multimedia presentation may offer new opportunities and could be the subject of new research.

2.2.6 WP1 Scenarios

The different circumstances under which warnings will be disseminated was the second step in the production of WP1.

It should be noted that the scenarios have some overlap. For example, a proportion of the audience may be travelling on foot during a catastrophic event. Also, some channels are suitable for many scenarios and others are only really applicable to one or two (see the matrix of applicability).

The scenarios were well received by the EA and by the National Steering Committee for Warning and informing the Public (NSC WIP) as a framework in which channels can be viewed. All of the scenarios except G, inter-organisation warnings, have been adopted by the Cabinet Offices' Civil Contingencies Secretariat.

2.2.7 Scenario A: catastrophic event with short lead time

This was included as a worst case, it stresses the message delivery rate limitations of communication channels. It, therefore, favours broadcast channels. A high impact, low probability event affecting many people, is most likely in an urban area. The implications of covering a wider geographical and rural area could also be considered.

A large body of evidence (e.g. Drabek 1986) shows that panic often portrayed in disaster movies is mythical. In general, the more at danger a group of people believe they are in, the more altruistic they become. So rapid, clear warning of impending peril should trigger useful response not adverse reactions; the fear of panic should not stop operators from issuing such warnings.

2.2.8 Scenario B: travelling user on foot – warning of current location

This was included to show the weaknesses of technologies that favour static recipients and may have poor propagation to mobile audiences.

2.2.9 Scenario C: travelling user in vehicle – warning of current location

This was included to show the weaknesses of technologies that may cause unsafe distractions and may not apply to audience members of scenario C.

2.2.10 Scenario D: travelling user remote location

This scenario covers those who wish to know of flooding in a particular place regardless of their location.

Certain cases have been identified to justify the inclusion of this scenario:

- Flooding on highways, route planning.
- Help someone else, especially those vulnerable or interdependent.
- Protect property while absent (at work or a holiday home, for example).

These personal circumstances will lead to different preferred channels, for example some may prefer an e-mail alert while others may have no access to such communication.

2.2.11 Scenario E: static person in own dwelling

The most commonly regarded scenario is that of people in their homes. It is a crucial focus to address this scenario as it is stipulated as a target for improvement by central government.

2.2.12 Scenario F: static person at place of work

A fair proportion of many people's lives is spent at work. A mix of technologies to satisfy the other scenarios may address the needs of those at work, especially scenario E.

However, the fact that those at work are a special circumstance and the need to know about flooding whilst at work and at home justifies their inclusion as a specific scenario. Also, it was felt that warning could be implemented by extended work place health and safety guidelines.

2.2.13 Scenario G: inter-organisation warnings

The need for inter-organisational warnings is understood. However, to do each inter- organisational link justice would require a study of similar (if not greater) size to the project as a whole. This is compounded, as each organisation will have different structure and different requirements such as content and presentation of information.

The Multi-Media Warning Dissemination System (MMFWDS) could explore this scenario in more depth.

2.3 WP1 Matrix of applicability

2.3.1 Candidate technologies

A simple means was sought to show which channels are appropriate to which scenarios. A matrix of applicability was produced to fulfil this. Channels included in the matrix are existing and possible technologies. Technologies already in use by EA analysed in WP1 were:

- Automatic Voice Messaging
- Loud hailers
- Sirens
- FAX
- Conventional broadcast media
- Flood wardens – door knocking
- Internet – pull
- Teletext
- Special signage

Technologies thought to be of possible use for warning by EA were:

- Simple Messaging Service Text messaging
- SMS
- Wireless application protocol pull
- E-mail
- Internet – pushes
- Advanced signage
- Tickers on standard TV
- Digital TV
- RDS Radio Data System Program Type 31
- Radio Data System Emergency Warning System
- Digital audio broadcast
- Power line communications

More advanced technologies on the horizon that may be of use in the identified warning scenarios were:

- Fire alarm look alike concept
- SMS Cell Broadcast
- 3G and 4G mobile phones
- Ad hoc networks
- Bluetooth, ZigBee & other wireless protocols
- Light
- Ultra wide band
- Software defined radio and software based communications

The matrix addresses the public's needs: the possible nature of presentation of flood warning messages in the identified scenarios.

A mix of technologies should be sought for the reasons stipulated in 4.1.1. The final work package should consider gaining the maximum audience for the minimum cost. This will have to include checking the scenarios served for given selections. The figure below shows which technologies could be applicable against each scenario; these will be ranked in a later revision.

	Automatic Voice Messaging	Loudhailer	Siren	Fax	Door to Door	Conventional Broadcast Media	Special Signage	Internet Pull	RDS Program Type 31	RDS Emergency Warning System	Digital Audio Broadcast	SMS (Mobile Text Messaging)	SMS Cell Broadcast	WAP Protocol Pull	E-Mail	Internet Push	Digital Interactive TV	Power Line Communications
Scenario A Catastrophic Event			📄			📄			📄	📄		📄	📄					📄
Scenario B User on Foot		📄	📄				📄				?	📄	📄	📄				
Scenario C User in Vehicle		?	?			📄	?		📄		📄	🖱	🖱	🖱				
Scenario D Travelling User (Remote)								📄				📄		📄	📄	📄		
Scenario E User at Home	📄	📄	📄	?	📄	📄		📄	📄	📄	📄	📄	📄	📄	📄	📄	📄	📄
Scenario F User at Work		📄	📄	📄				📄		?	?	📄	📄	📄	📄	📄		
Scenario G Inter-Organisation				📄				📄		?	?				📄	📄		

Figure 2.2 Matrix of applicability

Scenario A - *Catastrophic event with short lead time* is likely to be costly and/or have limited coverage if using traditional means alone (e.g. siren). More economic means could give coverage to most people to a suitable level of satisfaction. The final analysis document will address this issue.

There is an obvious advantage to certain mobile technologies such as SMS cell broadcast, which could also address Scenario B: *Travelling user on foot, warning of current location*, too.

The selection of some technologies can have multiple benefits. For example, with RDS, which gives a uniquely strong coverage for *Scenario C: Travelling in vehicle*, but can also address Scenario E: those at home.

Scenario D: *Travelling user remote location* brings special concerns and demands very fine targeting. This is likely to favour SMS and e-mail in particular.

Scenario F: *Static person at place of work* may be able to be addressed via HSE legislation and risk assessing.

Scenario G: *Inter-organisation warning* should be able to be addressed by a two stage approach. Firstly, selecting a coverall channel (e.g. Internet Push/Pull) and secondly by developing applications that utilise this channel but have specific presentation.

2.4 WP1 Protocols

The following relevant standardised and open protocols were identified:

- Common Alert Protocol (CAP)
- Tpeg Environmental Information and Alerts (EIA)
- Geographic Mark-up Language (GML)

CAP is developed by the Public Partnership for Warning (PPW); it has been accepted by Oasis as a draft proposal and is expected to become a W3C standard. After dialog with QinetiQ and the CAP workgroup, CAP now has improved GML support.

Tpeg EIA has binary and XML flavours, is supported by the European Broadcasting Union and has being considered for EC standardisation. Although its geospatial elements are more primitive than that of CAP, it has a distinct advantage that the related Tpeg standards are already being realised in commercial products.

GML is fast gaining acceptance as the *de facto* electronic mapping standard. Given the importance of geospatial issues to flood prediction and flood warning, it would be beneficial to the EA to track the progress of this standard also.

2.5 WP1 Conclusions & recommendations

Heterogeneous systems are desirable for the following reasons:

- Increased flexibility, EA would have more channels with different properties to chose from
- Increased robustness as more redundancy would be built into the system
- Increased effectiveness as research shows that recipients typically seek confirmation with secondary channels
- Increased choice for recipients

A heterogeneous system can be shown with an adapted SMCR diagram:

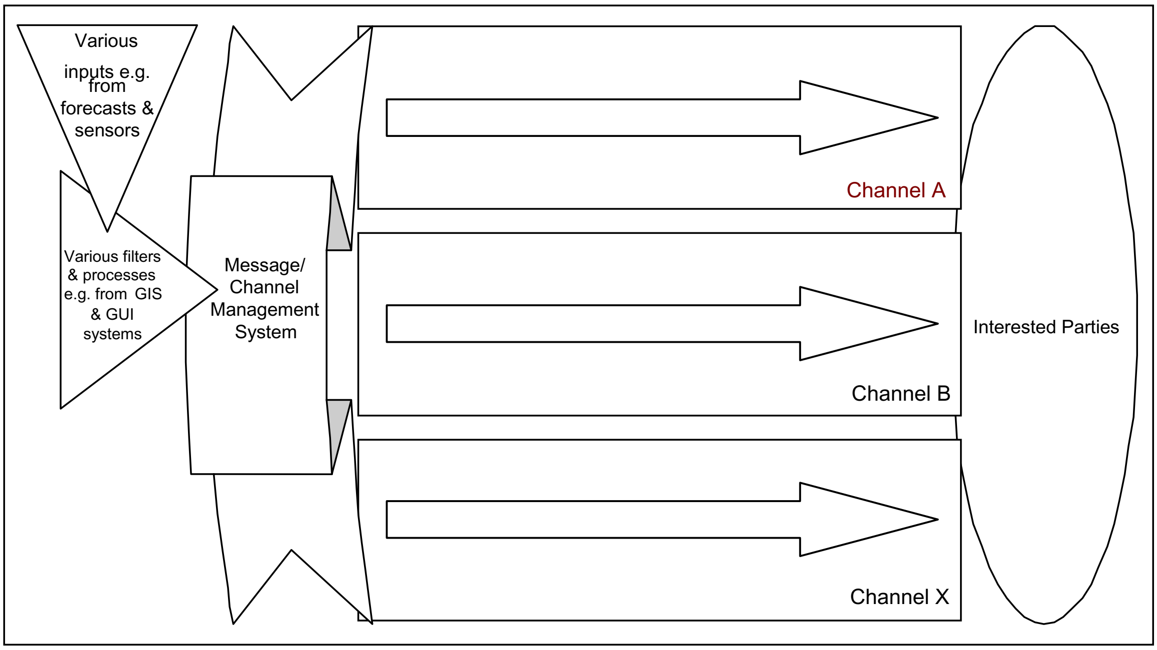

Figure 2.3 SMCR heterogeneous system

Hierarchical systems are recommended because by layering communication channels, a new 'virtual' channel can be conceived that has otherwise impossible characteristics. For example by having a broadcast first leg and an unicast second leg the system can have speed close to that of a broadcast system but also have receipting facilitated.

Layering of communication channels can be arranged so that from the recipients viewpoint they are in direct contact with the sender and have properties not possible without layering.

A hierarchical system can be shown with an adapted SMCR diagram:

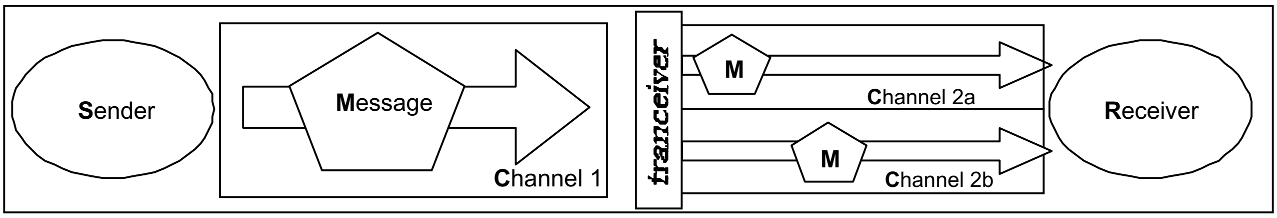

Figure 2.4 SMCR hierarchical system

2.6 WP2 – Requirements' SMCR models

All requirements for actual warning services must be traceable back to the publics' need to take action or to have action taken on their behalf. Requirements for trial systems should focus on determining on how channels can contribute to actual warning services i.e. the trial systems will not necessarily have all the requirements of actual systems. Also trial systems may have extra requirements and details on what information is required from the trial.

Full treatment of requirements for any particular trial system will be undertaken as part of the development of that system.

How trial systems differ from actual systems was explored in the WP2 SMCR diagram below.

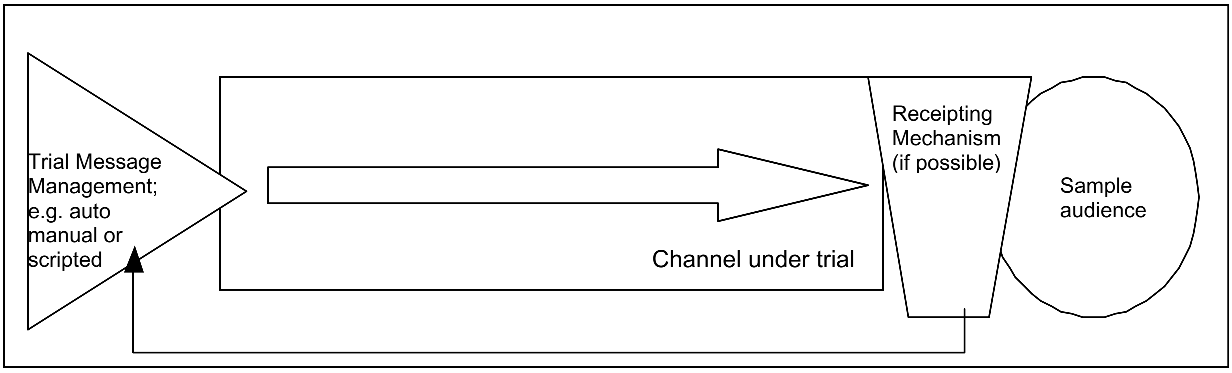

Figure 2.5 A view of a general channel trial system

2.7 WP2 - Identified users

The following types of stakeholders were identified for flood warning trial systems:

2.7.1 EA system administrators

Administration duties concern how channels can be configured: parameters, thresholds, and operator permissions etc. The nature of requirements pertaining to administrators will be important to both actual and trial systems but will largely depend on the capabilities of the channels in question.

2.7.2 EA system operators

EA system operators are responsible for the dispatching of warnings to the public. Their roles are likely to change as the MMWDS is introduced, used and better understood. Given that requirements are based on these roles they may also change. However, one can assume that they will remain related to message dispatch.

For some trials it could be acceptable to send messages automatically thus reducing the cost. The use of real sensor/forecast data could be avoided to reduce costs further; e.g. a script could control the dispatch of test warnings.

Where no EA system operator users are involved in the running of trials, their needs and impact will still need to be assessed to judge the suitability of particular communication channels and systems using them.

2.7.3 Message recipients

The following WP2 diagram shows how individual channels used by the MMWDS can be modelled from the recipients perspective. It is of the heterogeneous approach recommended in WP1; here the different channels are also likely to be of a different nature so they can be optimised for purpose (e.g. a siren for alerting and a free phone help line for informing).

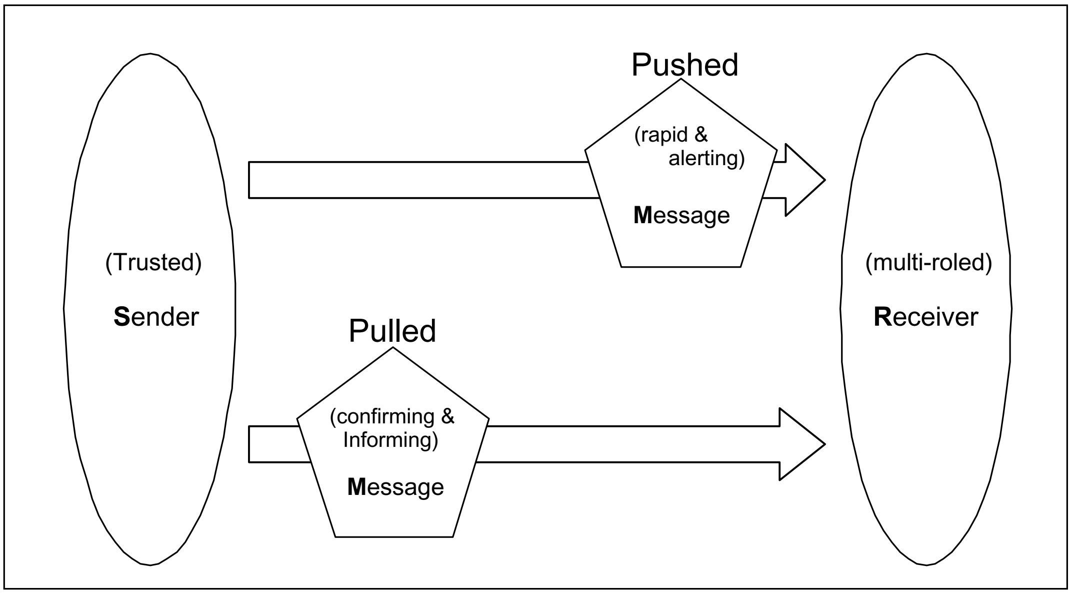

Figure 2.6 Ideal SMRC model (end recipients view)

The channels have been intentionally omitted from this diagram. Strictly speaking the recipient does not require the channels, only the messages they bear. 'Channels' are such an obvious part of any infrastructure that it is fair to consider them in requirements analysis. By including channels, useful requirements related to channel, rather than the message, can also be alluded to.

The public recipient end user type is very complex and can be categorised in many ways. These include, but are not limited to, by scenario, by geographic and demographic constraints.

Trials could be concerned with many aspects of warning, such as improving message content, presentation and delivery targeting. Even if a trial is primarily concerned with the technical communications aspects of a channel, it should seek to determine as precisely as possible the audience reached; not just in numbers but also the nature of those people reached.

Sometimes this may be a prime purpose of a trial: to determine how audience coverage could be expanded. When the results of several trials are combined, an understanding of who is covered by which channels will be possible.

2.7.4 Trial stakeholders

Members of the Project Board and panel are users of trial systems in the sense that they need to be confident in the trial system and its conclusions. Related projects will have an interest, in particular the MMWDS; and professional partners such as the Met Office may also use information learned.

2.8 WP2 - Requirement categorisation

The EA tend to view requirements and problem areas in the following categories:

- Service coverage
- Support
- Special devices
- Recipient costs
- Registration and database systems
- Recipient preference requirements
- Delivery reporting and management

2.8.1 Audience coverage

It is unrealistic to expect to approach 100% coverage. A simple percentage can measure those members of the UK at risk who are covered but such a number would be misleading unless it takes into account the different sub-groups of recipients, the scenarios they are likely to be in, and whether they are matched by at least one, preferably two, channels of dissemination.

Coverage can be expected to increase in the long term assuming the promises of “pervasive” or “ubiquitous” computing are realised and gradually adopted into society. In these visions consumers are able to use services from any provider, with any device, and through any communication channel available in a world where computers and communication channels are “everywhere” (e.g. part of all their electronics goods in a "networked home" and even in people’s clothing as "wearable computers").

2.8.2 Targeting

This aspect is in regards to the proportion of people receiving warnings that actually required warning For example a television broadcast is bound to reach audience members who are not affected and do not require any warning. This aspect could be measured as a percentage; based on a ratio of those who received a *required* warning and of those who received an *unnecessary* warning.

Many technologies make the request for messaging easy for some recipients, providing very fine grain, controllable targeting. These are especially useful for modern unicast (or multi-unicast) messaging services such as e-mail and SMS, This is termed a user-triggered push in the project.

Such unicast signalling is also possible in a broadcast channel. Some receivers can be configured to ignore most messages and only present those that are relevant to the recipient. This can be thought of as a multi-tier system where the processor is acting as a channel, filtering the broadcast communications and converting them into what is unicast from the recipient's perspective. Where recipients can be individually identified by those dispatching messages (e.g. by postcode / house number or an arbitrary system) the messaging can be perceived as unicast from the sender's perspective too; messages can be sent knowing they will be received by a single recipient.

Multi-cast messaging is coarser grained that unicast. Instead of per recipient it can be thought of as per sub-group. This could be done geographically for example and one message sent to a whole street. This is equally possible in a broadcast channel and should increase the message throughput capability in comparison to unicast in direct proportionality to the size of the groupings (10 recipients per group == 10x throughput).

2.8.3 Speed

This aspect is simply the measured rate of warning delivery. Ideally it would include only properly targeted (see above) messages and measurements. From the recipient's perspective, messages need to happen at least before it is too late to respond. It is assumed that the only reason a warning could be too early is if forecasts have changed and new messages are then made necessary. It is assumed that this is dealt with elsewhere i.e. in forecasting systems so the certainty is measured against the impact of the event and the necessary lead-time for any response. The levels of warning could also be used to address this issue. If certainty of forecast is not sufficient or that the period is large, watches can be issued rather than warnings or alerts.

The mode of communication will be a prime deciding factor in the speed of delivery of the message where, in general, broadcast systems may be favoured.

2.8.4 Cost

The costs of all interested parties should be minimised as much as possible. Any costs to recipients may deter message reception, which needs to be avoided. Ideally, there would not be any tariff to the recipient associated with the reception of a warning. It is believed that ongoing costs such as being charged monthly, or on a per message basis, would be less acceptable than a small one-off charge. An initial charge could be offset against cheaper household insurance for example.

Costs to the EA need to be easily controlled and be understood in terms of the QoS provided i.e. the value returned. One way to help control costs is to educate the public to expect only one pushed message and then to use broadcast pull methods for confirmation purposes; push channels can be particularly expensive to communicate across.

Where multiple push channels are required, receipts could be used so that, in the event of delivery failure, further channels/messages can be sent intelligently, using the channel redundancy.

This aspect could be measured as the cost per message, the cost per recipient or the mean total cost per incident. Costs should be identified for all interested parties. Cost may vary with the size of audience for any incident. It would require full messaging simulation to understand the costs per flood event, per sub group, per scenario, per channel; in particular, intelligently managing multiple push channels as mentioned in the paragraph above.

2.8.5 Content

Many channels have no choice of content type. AVM, for example, can only convey audio (voice) messages. Channels that are essentially digital data links typically can carry any digital data, such as encoded voice, video etc.

Such content rich methods of delivery can sometimes be further enhanced by the use of presentation devices that are flexible and configurable by the recipient. For example Tpeg-EIA systems can display messages in any language regardless of that of the originator.

A subjective scale is probably the most meaningful measure for this aspect. For certain scenarios and/or audience sub-groups, it may be possible to define more objective scales than would be possible for one that attempted to cover all.

Separation of the content and presentation can be ambiguous if not properly addressed.

2.8.6 Presentation

This mainly covers recipient interpretation, suitability to particular scenarios and audience sub-groups. Determination and measurement of this aspect will often rely on feedback (e.g. by questionnaire or interview).

A simple set of categories and heuristics is probably the most meaningful measure for this aspect. For certain scenarios and/or audience sub-groups, it may be possible to define objective scales.

Spatial models of perception should be considered for the exact nature of the presentation of messages. The audience's focus is considered to determine how likely they are to notice the information that is competing for attention with information from other sources. Though this is usually simple common sense, the application of the model can verify the legitimacy of the presentation used (Cheverst *et al* 2001). These parts of the presentation aspect may have their own measures if deemed necessary.

2.8.7 Receipting

Receipting has several uses:

- Determining QoS as some measure of audience coverage and message reception rate.
- Multiple push channel management.
- Targeting door-knocking to those who have not yet received a message (can be thought of as a form of the above point).

Per-recipient receipting may not be practical or cost effective for large-scale dissemination or for particular channels. For example, if receipts were being delivered over a data link they would decrease available bandwidth and could complicate management systems. If per-recipient receipting is not undertaken for a particular channel, samples could be used to determine the rate of successful delivery for QoS measurements.

Receipting mechanisms for partner organisations (e.g. the emergency services or BBC) is crucial to operations. The impact of non-communication with such organisations will be far greater than that of not informing any one particular member of the public.

A measure for receipting aspect could be borne from the cost per 1000 messages receipted and also a measure of certainty (e.g. if samples are used). The actual level of *reception* itself is dealt with in the “Coverage” aspect above.

2.9 WP3 – International perspective

WP3 reviewed the systems in Australia, Austria, Canada, Denmark, Finland, Japan, The Netherlands, Norway, Sweden, Switzerland and the United States of America.

Of particular interest was the use of RDS PYT31 in countries such as Norway and the hierarchical and extensive infrastructure employed in the US' Emergency Alerting system.

International alerting efforts were also presented. The Global Disaster Information Network (GDIN) was proposed as part of vice-president Gore's initiatives. It seeks to provide an integrated solution that would allow international warnings to be broadcast and to also enrich the constituent existing systems.

The money was solely American and the GDIN was affiliated with other American initiatives such as the Partnership for Public Warning (PPW). This would indicate that the GDIN line would closely follow the PPW ideals and proposed standards such as the Common Alerting Protocol (CAP). Some members have shared appointments with GDIN and PPW; these would be ideal candidates for the NSC WIP to target for dialog.

Since the completion of WP3, GDIN activity has picked up

3 Single channel trial options

3.1 Introduction

This section describes how the decisions were made on taking the project forward through consideration of testing communication channels separately as originally intended and through dialogue with the EA.

3.2 Original options

At the outset it was imagined that a cost benefit process would select a suitable dissemination channel.

At the Phase 1 closure meeting, QinetiQ and EA ran through the options for single channel trial possibilities. It was agreed that none of the options would be useful to the EA. The channels and the reason for non-trial suitability are as follows:

- **Advanced AVM -** results would be product specific. EA's existing knowledge and further international dialogue would allude to best options. Risk well understood technology that is already being integrated with the MMWDS. The cost of the telephone calls still has to be paid by the EA. This is in the region of £60k for the average flood event.
- **Special signage –** already being developed and under trial by the EA.
- **Internet pull –** already being addressed by the EA.
- **Internet push –** equipment needs to be on and connected, may be applicable when Broadband Britain comes to fruition.
- **RDS –** simple audio only (albeit with very limited length text), effective, used around Europe, good adoption by manufactures. Useful to those in scenario C.
- **RDS Emergency Warning System –** More advanced and flexible than RDS. Not adopted by manufactures.
- **SMS unicast –** under trial by the Office of E-envoy.
- **SMS cell broadcast –** useful to those with mobile phones but legal provision is still an issue.
- **DAB –** far more flexible and higher data rate than RDS.
- **Power line communications –** already under trial in the NE by David Hay.
- **Wireless ad-hoc mesh networks –** could use air interfaces such as DECT and its DPRS, well adopted, inexpensive and highly capable.

3.3 Option selection

In discussions with the EA few of the options seemed to be of interest that were not already in use or under trial elsewhere. EA decided that investment would be best placed demonstrating the hierarchical dissemination and *ad hoc* community networks.

4 Demonstration system

4.1 Introduction

Work in Phase 1 identified the themes for improvement to be demonstrated to the EA. These themes are:

- Heterogeneous channels to provide resilience, flexibility and confirmation
- Hierarchical channels to provide otherwise unachievable channel properties e.g. low cost rapid delivery of broadcast systems with receipting of unicast messaging
- Enabling channels to be used in systems beyond warning and also of use in response
- Use of common and open standards
- Improving the identified seven aspects of service:
    - Audience coverage
    - Targeting
    - Speed
    - Cost
    - Content
    - Presentation
    - Receipting

4.2 Heterogeneous and hierarchical approach

There can be no one magic solution. None of the technologies can address all identified scenarios. So the only way forward is to have a heterogeneous approach; one that has a mix of technologies to provide as wide an audience as possible.

Furthermore, redundancy gives resilience. The more channels that exist to propagate messages, the higher the probability that the intended recipients will receive the message: even if some channels fail, others may succeed.

Research shows that members of the public who have received warnings typically seek confirmation via consistent and multiple reliable sources before taking requested action (Drabek 1986). Whichever message is received first will make the audience more receptive to following messages. This increase in receptiveness will hopefully be to the level such that the audience actively seeks confirmation messages (e.g. turns on a radio).

If only one message is received, or if messages are received via only one channel, there is a chance that no action will be taken by the public.
A multi-tier approach is in itself desirable, as it can allow the mixing of otherwise mutually exclusive properties. For example, channels that are broadcast in nature have large throughput of messages and require less precise data.

Unicast channels allow finer granularity of targeting but can require very accurate data that may not be available.

By choosing the correct channels for each tier, characteristics that would be difficult to achieve can be more easily tailored.

4.3 Demonstration aim

To establish a greatly improved approach for the dissemination of flood warnings, by:

- reducing the cost of disseminating warnings
- improving the resilience of the system
- improving message targeting
- improving message delivery speed
- making the service more inclusive i.e. catering for all languages and for other specific needs

To develop a system that meets this approach, by integrating several communication channels and different types of presentation device. This system will allow demonstration of the approach and evaluate the effectiveness of the chosen presentation devices. To show how the same infrastructure, when in place, could allow co-ordinated community reaction to flooding incidents.

4.4 Demonstration architecture

The system was designed to be hierarchical having two primary legs:

- DAB carousel for Tpeg alerts
- Internet push – in case of demonstration area with poor DAB coverage; also supporting CAP alerts

However, due to difficulties including broadcasting arrangements with the BBC the DAB reception code was dropped from the development part way through.

The secondary leg is a wireless *ad hoc* network being able to integrate a number of presentation devices including:

- Simple alarm metaphors such as a vibrating pillow
- Common household devices such as fire alarms
- Common workplace devices such as burglar alarms
- Nomadic devices that could be useful to scenario C
- Complex display devices such as Digital Personnel Assistants

A possible arrangement of a final system is shown in the diagram below:

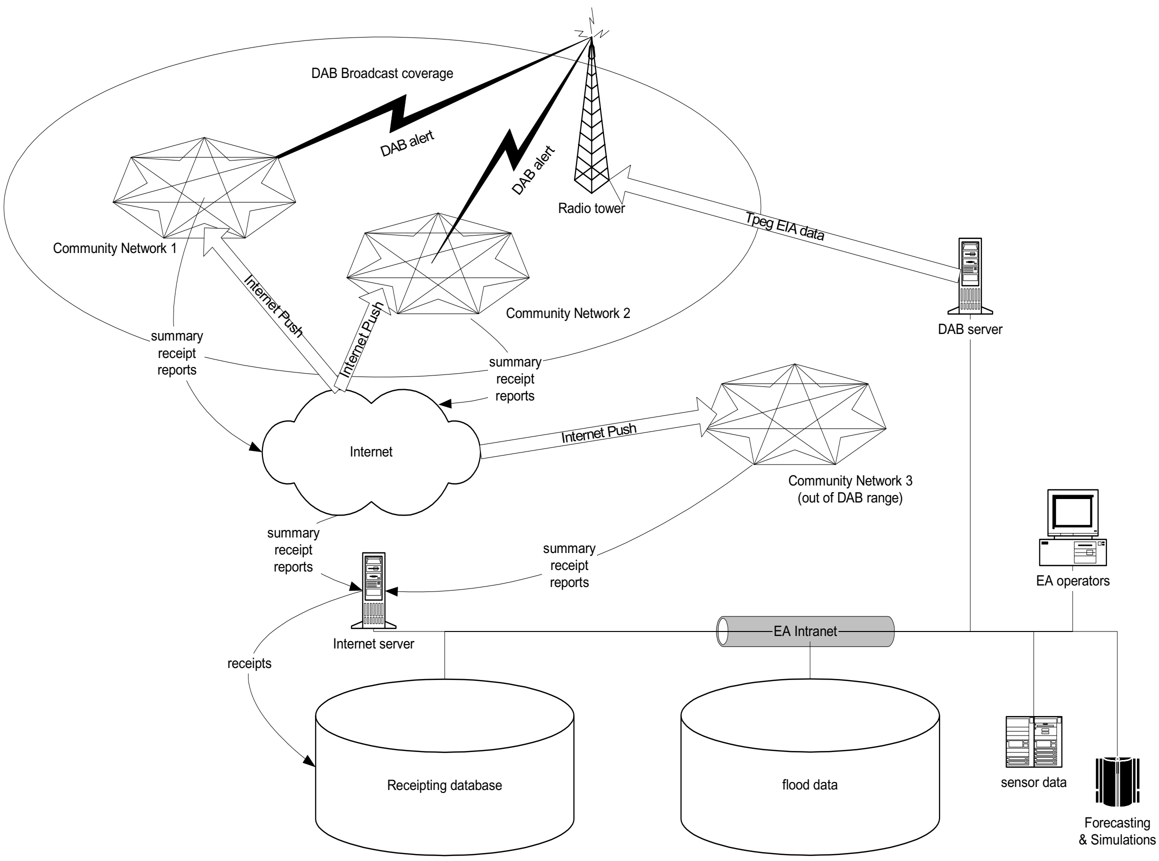

Figure 4.1 Demonstration system architecture

For demonstration purposes, tying in systems such as the forecasting and sensor data would be unnecessary.

Ideally the broadcast would be achieved with a mixture of DAB and Internet push giving flexibility, redundancy and confirmation channels. Of course the approach would support the use of similar WAN technology that is starting to emerge.

Tpeg and CAP messages were supported in the demonstration and the protocols tested for suitability. Both message formats supported the approach and were successfully employed. It should be noted that CAP support of GML may make it useful for scenario G: inter organisation communication. However the Tpeg support for multiple languages may prove to be of greater importance in the other identified scenarios by means of improving inclusiveness.

Each community network could have its own unique make up of presentation devices that also serve as transceivers propagating messages far beyond the range of the device that picked up the original broadcast. An ad-hoc network was demonstrated.

It has been shown how receipts can be collected in the community network and presented to the warden ready for dispatch to the EA as a summary report.

4.5 Software design

The system, being a prototype, had less quality control as the emphasis was to prove the possibility of a hierarchical and heterogeneous approach.

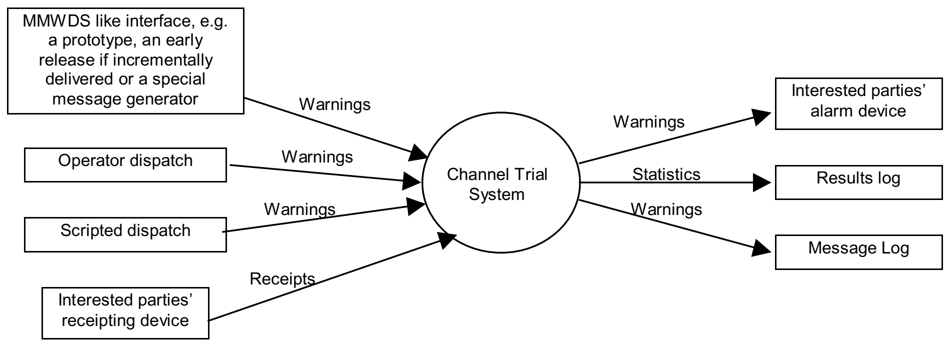

Figure 4.2 Demonstration system concept diagram

This diagram is taken from Phase 1 WP2. It closely matches the one used for the demonstration system except that an interface to the MMWDS was not pursued.

The software design and its implementation has been archived and is available to the EA, but it should be noted that the importance was placed on demonstrability rather than reuse or maintainability, which is only appropriate for a demonstration system.

Exempt from this general observation is the process and supporting framework that was developed.

The following diagram is taken from the development archive and shows the main software entities identified and their relationships.

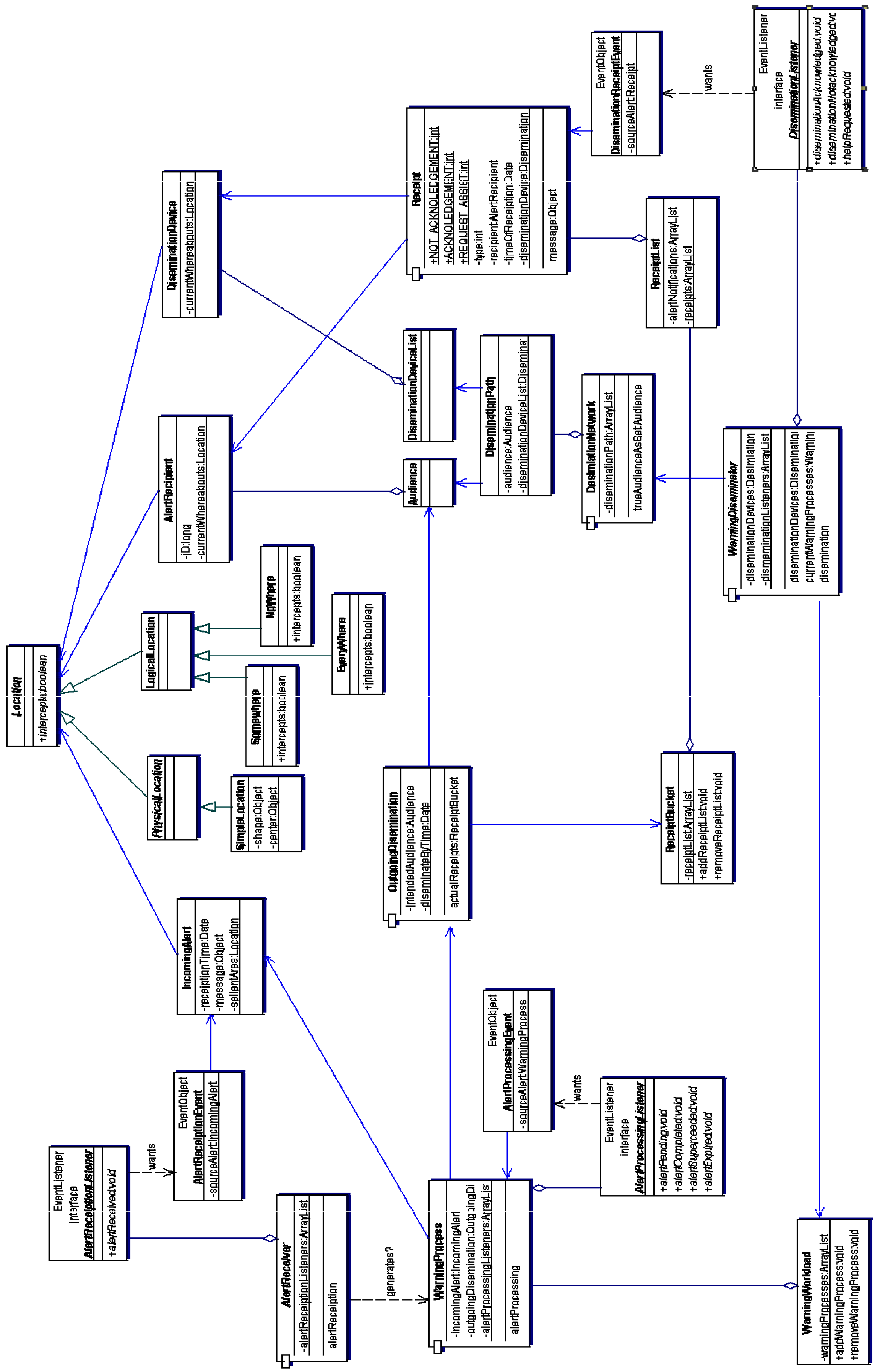

Figure 4.3 Framework developed to support warning process

4.6 Messaging details

The demonstration system used a text and icon messaging system that covered the following levels:

- all clear
- flood watch
- flood warning
- severe flood warning

The icons used were the standard EA flood watch icons.

Four receipts types were used:

- acknowledge
- request assistance
- offer assistance
- not acknowledge - no response received

The demonstration system was *ad hoc* so that all the devices that could be reached were automatically included in the recipient lists, even those never encountered before. The warden has the ability to alter those in recipient lists prior to initiating the dispatch process.

The demonstration showed some of the utility of the devised process and supporting framework. For example, new messages overwrite preceding ones; so that a newer "flood warning" is shown and not blocked by an older unacknowledged "flood watch". This improves situational awareness for asynchronous messaging in scenarios.

Scalability of the process and supporting framework is designed to simultaneously address:

- multiple warning sessions each with different audiences and alert levels
- each recipient having multiple receiving devices
- each receiving devices having many recipients
- recipient requiring most salient information
- recipient requiring only a limited number of repeat alerts (so as not to overwhelm or annoy)
- many other related issues such as summary receipting from communities to the EA

4.7 Distributed software for community flood response

There are several applications that could be distributed over the community network that would enhance its use beyond warning and into the domain of response. Some of those types understood to be of importance to flood response are briefly described below.

Multicast messaging could be enhanced similar to email lists or "reflectors" for simple command and control applications. This would mean that those taking on particular roles in a response could be addressed by their roles, and such lists could be dynamic. So that a message sent to "door knockers" or "sandbag shifters" gets sent to those scheduled to, or known to be currently able to, accomplish that task.

More complex command and control tools could be employed such as effects-based planning tools developed for military needs.

Situational awareness tools are applications that are designed to allow a shared interpretation of events and a teams response to them, as a situation unfolds. This simple approach of allowing a common understanding and orientation to a problem can have a great affect on the achieved outcome.

Resource management tools aim to optimise the use of limited supplies so that they are employed most usefully. Candidate resources for community based flood response include humans, their effort and physical supplies such as sand bags.

Geospatial reasoning and multi-point route planning are of importance given the required rapid tempo of response; so that resource movement is achieved towards an optimum. Specialised enhancements could determine and respect the differing flooding patterns that occur for the given geography e.g. as waters retreat back after the main flooding event.

Digital proxies and movement context extraction would be possible with the use of nomadic warning devices. This could be used to enhance the above applications allowing them to use/show the current location of respondents and their previous paths.

A general observation is that whatever applications are employed they should be developed sympathetically so that they can enhance one another's operation.

4.8 Results

In March 2004 QinetiQ provided a practical demonstration of the recommendations of Phase 1, namely that it was possible and desirable to perform flood warning through a managed system of channels that was both heterogeneous and hierarchical in nature (as described in the previous sections).

Specific advantages demonstrated were:

- Pervasive alerting with multiple presentation device types
- Low operational costs compared to AVM etc.
- Dissemination rate close to that of purely broadcast systems
- Digital messaging to allow any form of content

- Message targeting can be that of multicast and/or unicast
- Messages can contain highly localised information such as who in your street has spare sand bags/needs help etc.
- Receipting would be available to the EA on a per individual basis
- Receipting to include assistance requests and offers of assistance
- Receipting delivered as summaries reducing incoming message tally to EA
- Community based response made feasible through add on distributed collaboration applications
- Improved scalability
- Improved utilisation of future increase in the abundance of communication channels

The last two points are new observations to Phase 2 and come from the deeper analysis of the problems involved and how the approach, its process and framework have been engineered to address them.

It was noted at the demonstration that the approach taken by Phase 2 improved all seven aspects of service identified in 4.1.

5 Conclusions

The aims of the project were successfully demonstrated to the project team and members of the project board. There were many interesting observations and comments that have been worked into this document. The approach of a mix of hierarchical and heterogeneous has shown to be feasible by practical demonstration.

The process and supporting framework is designed to be scalable and should be used for further development towards a trial system. Some of the outcomes of the approach (e.g. having a local list of those non-acknowledgements) have already been identified as being particularly useful (e.g. generating a list of those to warn by foot).

Each of many communities can be notified as the first leg in a hierarchical system in a matter of seconds. The rate of local dissemination depends very much on the number of transceivers in place and their networking (e.g. range, bandwidth, number of hops in a mesh etc.). However, in the demonstration system (an *ad hoc* network of very modestly specified equipment) the dissemination time for 24 units never exceeded thirty seconds. It is anticipated that acceptable delivery rates, and certainly great improvements over AVM, will be possible with emerging wireless protocols and licence free transmit frequencies.

The use of multiple presentation types was achieved by using the capabilities of the wireless warning units and integrating them with a Yale burglar system and domestic fire alarms. The exact form of presentation which would be most suitable for those with particular needs would be best be considered under a separate study. It is understood that there has been some work conducted by the EA both in this area and the general social implications of warning.

It was also demonstrated that the approach is agnostic to any particular equipment implementations. What is really important is the general approach itself, its process and the underlying framework that supports it. So as technology develops in these areas (e.g. 4G mobile phone technologies) new equipment should be readily embraced by any deployed systems. The domestic adoption of wireless technologies such as the IEEE 802 specification family will provide more routes by which warnings can be delivered to their target audiences.

Multiple reception channels do pose technical problems, but these can be surmounted. In a pervasive computing world, where PCs, mobile phones, TVs, and ZigBee enabled refrigerators are all wireless ICT, the new problem is nuisance warning. The process T15 defined and the design of the software framework tackles this by using multiple concurrent warning sessions, each with their own target audience list. So when a recipient has acknowledged the notional correct number of warnings (e.g. two) the remainder yet to be delivered are cancelled and removed from the system. With this scaleable design the future only opens more possibilities for the managed delivery of flood warnings through multiple channels.

It is likely that such a system would be of use to the EA to disseminate other information such as air and water quality and that such wireless technology would be useful to certain other processes undertaken by EA personnel. Also there may be community-centric messages that could also be supported such as neighbourhood watch schemes.

6 Recommendations

The primary recommendation is that now that the concept has been validated a trial system should be developed. Ideally this would be sited in an EA Area office using a target community that is known to be committed towards self-response to flooding.

Given that the EA is likely to be only one of several reception channels for alerts an effort should be made to track, and adjust to, on-going open standards alert developments. This is important so that technological developments made using standards other than Tpeg could be utilised by the EA for their own flood warning programme. The Common Alerting Protocol is of particular note and has undergone its initial standardisation through the standards body OASIS.

The UK Government approach to emergency management and the resultant Civil Contingencies Bill rightfully means that responses will always be seen as multi-agency concerns. This programme has embraced this concept from its outset, through scenario G - inter organisational warning, so the messaging process resultant fits well with these requirements. The findings of any trial system should be fed into appropriate channels in this direction such as the Government Information and Communications (Ops) department at the Cabinet Office and the National Steering Committee for Warning and Informing the Public.

The Health and Safety Executive should be consulted in regards to scenario F, a user at work. Coastal flooding, for example, could provide justification for this where lead times may be short and the results devastating. The HSE's involvement would hopefully result in modified working practices.

Through a trade organisation the insurance industry should be consulted about the possible impact of this research. Both the industry and its consumers have vested interests; receipted warnings could be strategically used to improve the overall service, reduce fraudulent claims, lower premiums, increase insurability of property and further engage the public. The alerting infrastructure itself could be facilitated with the industries involvement and provide the means for funding or subsidising the purchase of domestic warning units.

Multimedia channels could support highly emotive messaging to mobilise community response. This could be an interesting future research area. Sensor platforms are in place for detecting other environmental factors, for example, those put in place towards EU directives. These could have added value in monitoring factors that are useful to flooding detection and prediction, and could also be used for the transmission of alerts. It is anticipated that the extra cost associated would be insignificant compared to the possible benefits though. From initial discussion with EA data monitoring researchers it should be possible to supplement local flooding information from other such initiatives.

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8 Bibliography

8.1 Internet links

Over five hundred web sites were used in the gathering of information, documents and opinion. Links to some of the more general ones are given below.

- http://www.alertsystems.org American flood warning systems.
- http://www.bbc.co.uk/rd/ BBC Research and Development.
- http://cindi.usgs.gov Centre for Integration of Natural Disaster Information.
- http://www.cellbroadcastforum.org forum for SMS Cell Broadcasts.
- http://www.colorado.edu/hazards academic *Disaster Research* resource that has a monthly newsletter.
- www.dartmouth.edu\artsci\geog\floods\index.htm includes a flood observatory.
- http://www.disasterlinks.net includes many disaster-related links.
- http://www.edis.ca.gov Internet push & pull of emergency warnings in California.
- http://www.fema.gov Federal Emergency Management Agency.
- http://www.fhrc.mdx.ac.uk Middlesex University's Flood Hazard Research Centre.
- http://www.floodforum.net hosted by the Parliamentary Office of Science and Technology.
- http://www.hse.gov.uk\hid\land\comah\level3\5c99212.htm relating to warning signage.
- http://www.incident.com hosts definition of Common Alerting Protocol.
- http://www.nnic.noaa.gov/CENR Committee on Environment and Natural Resources.
- http://www.partnershipforpublicwarning.org a Public Private Partnership for warning the public, previously headed by Peter Ward.
- http://www.plca.net the Power Line Communication Association.
- http://www.ukdigitalradio.com UK resource for DAB.
- http://rds.org.uk UK RDS forum.
- http://sdcd.gsfc.nasa.gov\DIV-NEWS\earth_alert.htm Earth Alert project.
- http://www.wdc.ndin.net The Western Disaster Centre.
- http://www.worlddab.org Digital Audio Broadcast resource.

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