ITS comms – the CALM and efficient way

Nigel Wall introduces CALM, a simple concept that is destined to transform the way ITS applications communicate with each other in the future

Imagine a world where all vehicles have full connectivity to each other and to the global internet, ideally at broadband speeds, but at least having a narrow-band connection at all times. There is a massive range of services that could be supported. But how could that be done at an affordable price, and how would we evolve to a common solution with the rate of change of telecommunications? The CALM concept was created as a stable protocol framework that will support today's applications but opens the door for easy migration to include new applications and networks.

The acronym CALM is derived from 'Continuous Air-interface for Long & Medium range telecommunications'. The concept is simple: we assume that systems that host ITS applications (typically an in-vehicle unit) will have access to more than one communications systems. CALM offers a set of protocol standards that will allow the host system to route the necessary communications over the most suitable telecommunications system that is available at that time, based upon knowledge of the quality of service requirements for that application and the real-time performance of the available communications media.

New communications media which are designed from the outset to work with CALM will include Management Service Access Points (SAPs) that allow detailed information on the capability and instantaneous performance of that comms system to be passed to the intelligent routing management software. Existing communications media can be adapted to work with CALM, using a protocol adaptor. However, this will not be able to provide as much information as the media designed to be CALM compliant.

The set of CALM standards is being developed within the Technical Committee 204 of the International Standards Organisation, (Intelligent Transport), Working Group 16. (ISO TC204, WG16). The ISO WG is working closely with other international, national and European standardisation bodies to ensure that all interested parties are consulted.

Scope of the CALM standard

CALM standards can be used for vehicle-to-vehicle, vehicle-to-infrastructure, and infrastructure-to-infrastructure communications.

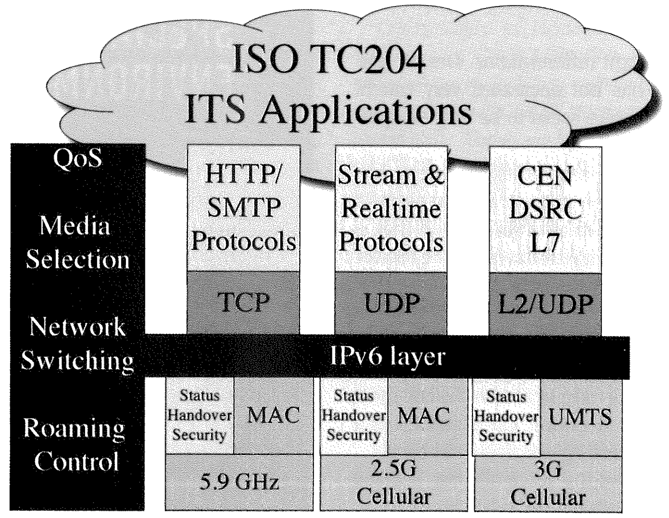


Figure 2: A simplified CALM architecture

New communications systems are being developed as part of CALM, whilst existing communications systems can be adapted to work with CALM, in order to allow intelligent routing.

Figure 1 shows some of the range of services that can be supported via CALM.

Benefits: Why do we need CALM?

Benefits of using CALM include:

- meeting today's communications needs whilst providing an enduring, robust, open, future-proof protocol architecture to allow inclusion of any new applications and networks into the foreseeable future,
- reducing the cost of using telecoms, whilst improving robustness and availability,
- encouraging the launch of new ITS communications services.
- allowing continuous operation as the vehicle crosses international borders,
- allowing a core ITS capability to be built into world cars, with simple adaptation to provide communications and applications tailored to each country's needs,
- simplifying in-service upgrade to use the latest and best telecoms systems.

Exploring these benefits in more detail

Telecommunications costs will be minimised whilst maximising the availability and performance by enabling the lowest cost network (for example a wireless LAN hot spot) to be used whenever this is available, yet allows immediate access to more expensive networks if the least-cost option is not available at that time. In an emergency situation it would be appropriate to use any communication systems available, irrespective of cost.

The business case for the provision of innovative and competitive telecommunications systems will be improved. The success of a new communications system is normally critically dependant upon providing near-universal coverage before the service is launched, and on a high take-up of a killer-application that will load up the network and assure revenues. However, CALM will allow any application data to be routed via the new network where the routing management system determines that this gives the best combination of cost and performance, with automatic drop-back to an established telecoms network in any area without coverage.

CALM will enable key applications to continue to operate whilst driving from one country to another, even if this requires a different telecoms network to be used in each country. With radio spectrum allocation managed on a national basis it is almost impossible to agree a common set of protocols and common frequency allocation for all countries. Of course the vehicle will still have to be fitted with an appropriate interface for each network to be accessed, or have a terminal that is programmable to interface to these different networks.

World-cars will be produced with a built-in application platform (in-vehicle unit) that can support generic and local/national applications (such as road pricing) as well as customer chosen value added applications.

CALM will provide a standardised point of flexibility that should help accelerate the deployment of ITS systems, so that applications and networks may each be enhanced, updated or replaced during the life of the vehicle. The service life of vehicles is increasing (typically 15 to 20 years) whereas communications systems have an ever shorter life (handset typically two years, and networks perhaps eight years).

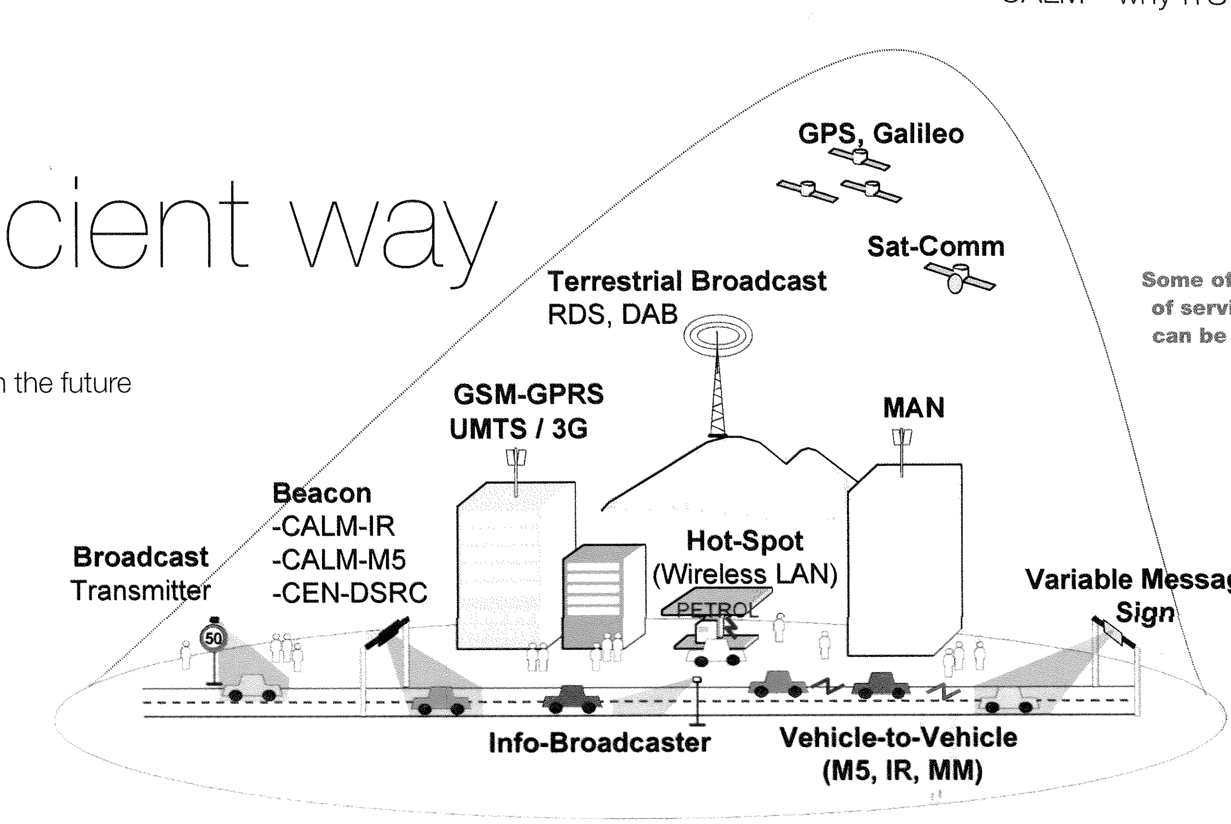


Figure 1: Some of the range of services which can be supported via CALM

Range of Applications

A comprehensive range of applications has been defined ranging from safety critical vehicle-to-vehicle control to entertainment services, including road pricing, collection of probe vehicle data, sharing of congestion information for dynamic route guidance, hazard alerts, remote vehicle diagnostics and updating of on-board software.

Safety warnings and instructions will be pushed to the driver, whilst other applications will be driven by the driver's preferences.

Standardisation Process and Current Status

ISO is established under the auspices of the United Nations, with approval of standards coordinated on a national basis. Decisions to progress standards eg to include new 'work items', and the approval of draft standards is by a formal voting process involving all the nations represented. The agreement to support a new work item places an obligation on the proposer and supporters to supply the expertise and effort needed to draft the standard. There is no central funding or project team to create the standards. Meetings are attended by people appointed as national representatives and others who have been invited by the convener. These are the people who create the standards: there is a minimum of formality at this working level.

Many of the CALM standards are at an advanced draft stage and one (Infrared) has been agreed and issued as ISO21214.

Architecture

An outline architecture is shown in figure 2 which is based upon the OSI 7 layer model.

The top part of figure 2 shows that a wide range of ITS applications exist. Some of these (such as web browser-based applications) will need reliable data transport. Other applications will employ their own error handling approach, and will require a simple datagram service that is fast and not unduly delayed. There will also be non-standard and lightweight protocols that need to be accommodated, such as that used within the CEN DSRC standard. Safety critical messages are handled with minimum delay and a minimal protocol overhead.

At the bottom of the diagram there is a representative sample of some of the communications systems that are to be included. Each one has an adaptation protocol associated with it to enable the status of the network to be monitored, and to assist in achieving handover and security.

The novelty is the black area. IPv6 has been chosen for communications routing (OSI layer 3), but this is supported by the CALM Management Entity, shown at the left hand side. The CME functionality is introduced in figure 2, whereas figure 3 shows the protocol modules involved. Some details (eg the full range of communications media) have been omitted for simplicity.

At the left hand side of figure 3 the CALM Management Entity is divided into an Interface Manager, Network Manager and CALM Manager.

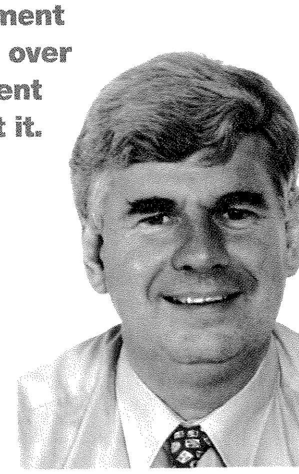
The Interface Manager interacts with the adaptation layers that provide status information on the communications media, and allows some direct control of the medium.

The CALM Manager interacts with the convergence layer that identifies the requirements of the applications (via a blue SAP). Note that the CALM aware applications will have a management SAP built in and will not need a convergence layer.

The Network Management Entity (NME) takes the Quality of Service requirements derived from the application and compares this with the current status information from each of the available communications media. The NME takes account of the media selection policy in order to determine the optimal choice of network. Figure 4 shows the principle involved.

'CALM has been in development on an international front for over four years - but at the moment very few people know about it. It is time to catch up.'

Nigel Wall, the Communications Research Network



Communications Research Network

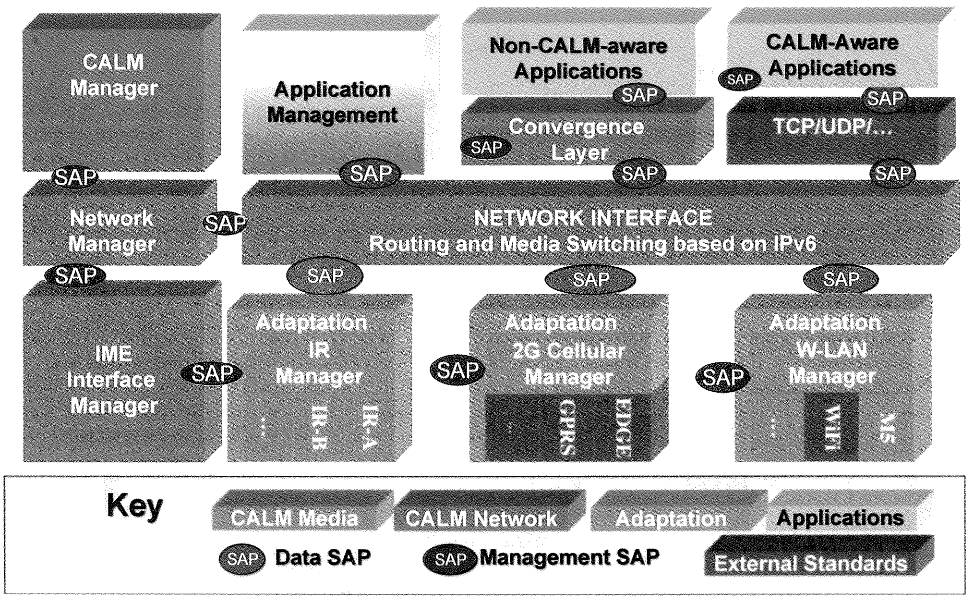


Figure 3: A more detailed breakdown of the architecture but not showing all the different networks which have been defined,

A CALM application uses the management SAP to express its requirements in terms of quality of service, urgency, throughput needed, and an indication of the value associated with the service being supported.

The media selection policy will have a set of default settings but is also likely to be user-configurable. In general the policy will be to select the communication media that will provide the best value for money. Where a low-cost service is not available a decision needs to be taken as to whether to use a more expensive comms service, or to delay the communication. An example would be the use of a satellite link for an emergency call following a serious crash: whereas a request to download a new game for a passenger's entertainment may be delayed until the next wireless hot spot is passed.

The NME will also manage handover between different communications media. If a link drops out, the NME should switch immediately to use a different medium, without any loss of data, by holding the session open.

Range of Networks

Why not just design the 'perfect communications system'? In practice, each communications system has been optimised to meet particular application needs and the operational environment. No single system would be optimal for all conditions. More importantly, it is unlikely that people would ever agree on the design! So we have to work with a wide range of media now and in the future. Diversity of routing, which increases availability is a further bonus.

Non-CALM networks for which adaptation layers are currently being developed include:

- GSM -GPRS & EDGE
- 3G - UMTS & CDMA2k
- Broadcast services – DAB & GPS
- WiFi
- Wireless MAN – WiMAX, HC-SDMA
- DSRC – CEN, Japanese & Korean
- Wired connections – CAN, AMI-C & Ethernet
- Personal Area Networks – Bluetooth & Wireless USB

However, most effort has been focussed on creation of new communications media that are designed from the outset to include management SAPs to provide the full set of status reporting and additional control functionality. These include:

- Infrared (IR)
- Millimetric Microwave (MM)
- CALM Wireless LAN (M5)

The development of the MM standard has been made possible because of the UK Foresight Vehicle MILTRANS project, which investigated the use of MM based systems for ITS applications, including the use of electronically steerable, phased array antennae.

The infrared standard builds on the learning from the successful use of IR technology for tag and beacon electronic toll collection and for the enforcement of the German Tollcollect HGV tolling system. Backward compatibility has been provided.

The M5 system is based upon the IEEE 802.11p wireless LAN protocol, and the IEEE 1609 family of standards. IEEE 1609 was developed as the Wireless Access in the Vehicular Environment or WAVE. Confusingly, this technology is also called Dedicated Short Range Communications (DSRC) which operates at about the same frequency as the CEN DSRC system. However, the American DSRC has nothing else in common with the European CEN DSRC. CEN DSRC specifies a low-cost tag with very simple protocol, based on modulation and passive re-radiation of a microwave signal that is received from the adjacent beacon. There is absolutely no compatibility, nor similarity of performance between these two systems. Needless to say that CALM is able to connect via either technology.

The M5, MM and IR media all support vehicle-to-vehicle and vehicle-to-infrastructure communications. The routing layer will also support ad hoc operation, where communications packets daisy-chain from vehicle-to-vehicle until a vehicle is within range of an infrastructure node. Of course each stage of that link could be implemented by a different medium!

IR and MM systems can be implemented as omni-directional or highly directional systems. M5 can also be made fairly directional. The CALM routing algorithm will make use of this directionality and a range of directions has been defined in CALM (figure 5).

These directional communications will be important for vehicle-to-vehicle communications, eg where warnings of extreme braking may need to be sent to following vehicles, but are not relevant to vehicles in front. Directional information and instructions are included in the management SAP's protocol.

Where next?

The CALM family of standards only defined the protocol architecture and the interface protocols between each of the blocks. How these blocks operate is down to the system designers. CALM entities need to be implemented and validated.

However, to be successful the benefits of CALM must be recognised widely to assure rapid adoption.

Technology Trials

Practical experimental implementations of CALM will validate the protocols and demonstrate the benefits that will be developed. These developments will also form the first step of development of marketable solutions.

In Europe there are several initiatives that will evaluate aspects of CALM. In particular the European 6th Framework CVIS (Cooperative Vehicle-Infrastructure Systems) integrated project is being led by ERTICO and will demonstrate a number of novel applications at test sites around Europe. These will use a common core technology that will incorporate CALM.

The Car2Car Communications Consortium is another collaborative project in Europe, aligned with the eSafety initiative. The C2C-CC has met with the CALM community and steps are being taken to align these activities.

A further EU integrated project that is about to start is SISTER, which will add satellite communications to the family of CALM networks.

There are similar linkages to national initiatives in the USA, and Far East.

Possible Additional Applications

Although the headline scope for CALM includes use for infrastructure-to-infrastructure communications there has been no active work in this area. There appears to be potential to enhance Urban Traffic Management & Control (UTMC) using CALM, especially if wireless communication is to be used. This expansion might also deliver a significant benefit for 'classic CALM' users as the infrastructure would become rich in access nodes provided for the fixed infrastructure, which would also support vehicle to infrastructure communications.

Other possible extensions would be to integrate initiatives that are currently perceived to be stand alone, such as Electronic Vehicle Identification (EVI) and the remote /automatic enforcement of eTachograph.

However, the supporters of any proposal to extend CALM must be willing to commit the necessary resources to complete the required work.

Additional communications networks

In several countries the emergency services use wireless digital communications based upon the European TETRA mobile radio standard. Given the importance of the communications carried by these networks it is conceivable that adoption of CALM would be a very attractive prospect. CALM would allow automatic selection of an alternative network if the TETRA network is unavailable at the point where it is needed.

Fixed networks used for ITS might also be enhanced by the ability to automatically divert data packets over an alternative route (possibly wireless) if the primary link fails.

Commercial commitment

Commercial decisions will be needed to ensure that CALM is built into vehicles and other ITS systems. The decisions will be based largely upon business case analysis, together with evidence that other system providers will be adopting CALM, so that critical mass will be achieved.

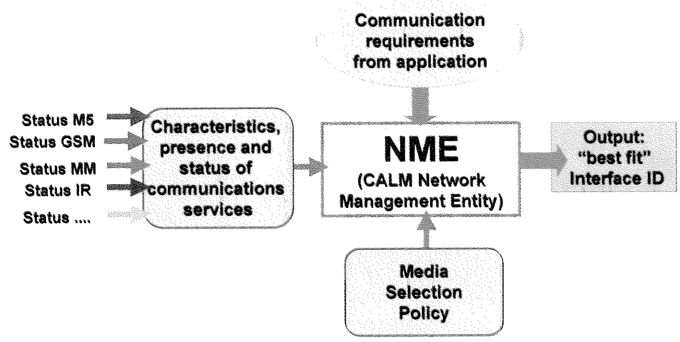


Figure 4: The principles involved in determining optimal choice of network

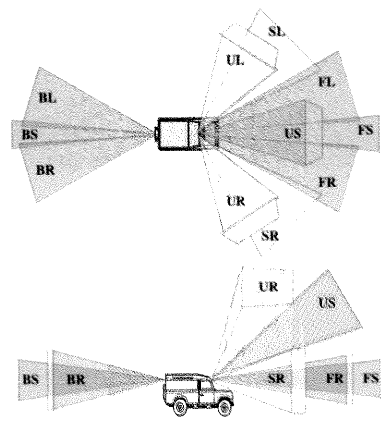


Figure 5: The range of directional zones which has been defined by ISO

There may also need to be political commitment to ensure that CALM is built into thinking on government led initiatives such as road pricing where CALM should facilitate implementation of multi-application in-vehicle units, to enable synergy, cost sharing and piggy-back deployment.

As with other activity to develop and launch new telecoms technologies, it is not sufficient to produce the standard and expect everyone to adopt it. Spectrum must be agreed for new CALM media, and roll out plans must be agreed between the stakeholders.

For instance, if one organisation intends to invest in the required fixed infrastructure of access nodes, it will need to have strong evidence that vehicle manufacturers will be installing compatible equipment in all new vehicles, and vice versa.

It is proposed to establish a 'CALM Forum' in the near future. This will work in a similar way as the GSM MOU (Memorandum of Understanding group) and WiFi Forum were established to agree and work towards common implementation plans etc.

Research needs

The Communications Research Network (CRN) has been spun out from the Cambridge MIT Institute as a not-for-profit membership organisation to stimulate downstreaming of innovation for the benefit of the members. The CRN has a Telecommunications for Transport working group which is planning to work on a number of CALM related activities, including:

- Security & Authentication vs Privacy issues:
  - probe data / road pricing / advertising
  - input to the new ISO work item on Privacy of Probe Vehicle data
- 100% Availability of Safety-critical mobile communications
- Migration strategies to switch to new technologies:
  - different product life cycles
- Geographic addressing:
  - absolute location
  - relative location
- Efficient ad hoc meshed communications:
  - speed to deliver information
  - minimisation of unnecessary message forwarding
  - locution & context aware routing
- Techniques for dynamic selection of mobile access media:
  - to meet application needs based upon current and predicted coverage for that location, and direction of travel
  - seamless handover between media, as the user moves through variable coverage
  - ultra reliable communications for safety critical applications
- Examination of the feasibility and potential benefits from wider use of CALM:
  - infrastructure-infrastructure communications
  - urban traffic management & control (UTMC)
  - other ITS systems

How to get involved with CALM

The next meeting of the CALM standards group is on 6-10 November 2006, in Newquay, Cornwall, UK. If you wish to become engaged with the standardisation process, the first step is to speak to the ISO TC204 WG16.1 Convener who is Bob Williams at bw_csi@compuserve.com.

Bob Williams is also the first point of contact for the CALM Forum. Bob can also supply a copy of the CALM Handbook which goes into much more detail than contained here.

To join in with collaborative R&D, and experimentation in the deployment of CALM, contact the Author at n.wall@communicationsresearch.net

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However, the opinions expressed and any errors in this paper are entirely down to the author.

CALM
continuous communications for vehicles