M2M in 2015: An Automotive Scenario

Modern automobiles depend on electronics and software, and by 2015 it is predicted that nearly 50% of the cost of a vehicle will be in its electronics. Cars today last for at least 10 years and many are still on the road nearly 20 years after they were manufactured. Yet the original manufacturer often earns income from only the initial sale and perhaps extended warranty services for a few years afterwards. Car makers are interested in ways they can develop longer - term service relationships with their customers, both those that buy the vehicle new and the second and subsequent owners. Keeping the car "connected" can form a key part of these initiatives. At the same time, highway and regulatory authorities see radio communications with the car as an enabler to make driving safer, and reduce pollution and congestion. But connecting the car is not straightforward and many issues have to be thought through to make a successful solution. We at Cognovo believe that SDR can be a powerful component of this and the following scenario helped to develop our thinking.

At the factory in Bavaria the latest version of one of the world's best-known luxury saloons has just entered production. At the heart of its electronics is a powerful processing engine and a very capable broadband radio transceiver covering the bands from 450 to 2600 MHz. These frequencies encompass the global cellular bands for systems ranging from GSM through 3G to LTE and WiMax; short-range systems such as Bluetooth and WiFi; new "white space" spectrum liberated through the move to digital TV; and the bands used for satellite navigation systems such as GPS, Galileo and Glonass.

The processing engine, based on a specific variant of Cognovo's MCE architecture, is sized to be able to deal with most future cellular standards, certainly up to LTE if not LTE-A. It is coupled to a powerful communications protocol processor and connected in to the central processing unit (which runs the main secure OS for the vehicle telematics) through the standard CAN-bus. The radio is designed to cope with all the required modulation and transmission formats. As the car electronics are developed, test software is loaded into the radio module to allow its operation to be verified in all the various operating modes.

During the years the car has been under development, the networks in operation and the frequencies they use have been changing. In Europe, operators are rolling out LTE infrastructure in the newly-released 800 MHz "digital dividend" bands, as well as 2600 MHz LTE base-stations in dense urban areas. At the same time, they are starting to turn off their venerable GSM networks at 900 and 1800 MHz, some re-farming this spectrum for 3G and some for LTE. In some countries, operators who enthusiastically rolled out 3G but have become overwhelmed with smartphone data usage are doing their best to replace 3G with LTE, taking advantage of its lower network costs and better spectral efficiency, as fast as they can persuade their users to churn their phones. Yet other operators who early adopted WiMax are starting to replace it with LTE since terminals are more available and cheaper, but need dual-mode devices.

A similar story unfolds in the United States, with the added twist of special bands like the 700 MHz "digital dividend" and the AWS band which are used nowhere else in the world (and even in the US different operators use them differently).

In Asia, especially China, though many networks use the same standards as Europe, TD-SCDMA and TD-LTE are specially important. Though not dissimilar to its FDD cousin, TD-LTE uses the radio bands differently, transmitting and receiving alternately on the same channel frequency. Countries like India, where traditional "paired" spectrum bands are harder to liberate, are also adopting TD-LTE though not necessarily in the same bands as China. Even in Europe and the USA operators who own suitable unpaired spectrum start to look at using it for TD-LTE.

As the amount of spectrum needed for a national TV service is reduced through the roll-out of digital TV, a wild card has appeared: not only is "digital dividend" spectrum released but the possibility

arises of using "white spaces" – TV channel frequencies not used in a given area for broadcasting – for other communication systems. The favourable propagation characteristics of these frequencies means that they start to be used in many countries by innovative operators for "M2M" communications – they allow vehicles and other systems to keep in touch even in the large areas of many countries where vehicles may roam but the population density is too low to justify cellular operator deploying mobile broadband.

With all this change it is hard to predict what network environment cars will enter as they start to roll off the line and get shipped to customer territories, and how that environment will change through the vehicle's lifetime. With this uncertainty a software-defined radio comes into its own. As the last production operation each car has its radio powered up in short-range WiFi mode, using a radio link to download final configuration data for the model's options and the necessary modem software for the wireless networks in use in the target territory. This software is pulled from a production database maintained and updated by a global M2M service provider, based on the networks it operates round the world and the alliances it has in place. For a particular car destined for an owner in the UK, the operator recognises that they need to make sure that the radio can communicate on its 900 MHz WCDMA network (preferred for best coverage) as well as 1800/2100 MHz WCDMA. Unfortunately these standards are covered by much essential IPR owned by Qualcomm and others, so an on-line payment system is activated to ensure that an appropriate royalty payment is made.

Once in country, the first time the car is started its radio module hunts for a free channel on the designated 3G system and registers its presence on the network. At M2M Central, a database file is activated with all necessary information on the car, its configuration, options, and status; and this file is mirrored in the maker's support systems. From this time onwards, as long as the car battery is charged, the car maker and the operator can keep track of it and monitor its status, and provide services to the owner: updating its map database; downloading new audio tracks; monitoring the engine management and drive train systems and warning the driver and manufacturer of possible faults; downloading software bug fixes for vehicle problems to avoid costly recalls; even through to providing call services to the driver and passengers in case of accident.

After a few months happily driving in England the owner takes a holiday in France. The operator not having its own network there, it must continue to provide service through a roaming agreement. Their partner, now owned by a multimedia giant, have adventurously turned off their 3G system (which never really delivered on its promise of mobile broadband) and upgraded to LTE everywhere. Pre-warned of the proposed trip through the EuroTunnel booking system, the operator's support system quietly downloaded LTE modem software days beforehand, ready for when the car popped up the other end of the tunnel.

After a relaxing break from driving, the car's owner starts it up in France – now the Galileo software on the radio module has pinpointed its position in Calais, the LTE software is fired up and the car registers through the network. Agent software in the M2M cloud negotiates a partial refund of the royalties paid on the UMTS patents. The car's satnav system downloading new maps of France as it goes, the driver heads off to the Pyrenees after keying the desired destination into the on-board navigation. Problem! He will be driving for many miles through a remote area where there is no cellular coverage. An expert system back in the UK determines that coverage is available through a white-space M2M system deployed to support utility telemetry and general emergency services in the area – after brief negotiation between software agents the right software is downloaded through the LTE network 20 km before the car leaves cellular coverage. As the car enters a deep gorge in the foothills a soft computer voice informs the driver that whilst emergency tracking and monitoring is still operating, he can no longer download new maps or multimedia content.

And so it goes on through many months and years of trouble-free and safe driving, the car always in touch with its maker's back-office systems that monitor its engine and safety systems, help to

inform the driver of necessary maintenance, downloads new engine management parameters as the manufacturer's research yields new ways of saving fuel, gently hints to the driver better ways to drive, keeps his maps up to date and the latest music on his hifi. And new apps can be downloaded, so for example a wireless LAN mode could be introduced to enable vehicles on a busy road to communicate with each-other to help to coordinate speeds, and improve safety.

When the first owner sells the vehicle on, the systems help keep track and develop a relationship with the new owner even though he might use an independent servicing agent. Even if the car were sold into a completely different country, the on-board system allows it to be tracked whilst the radio is updated to operate in the new territory (where perhaps GSM is still in use).

Back in the UK, the operator finally turns off their WCDMA network and the radio is updated to work only on LTE-A. Ten years later, after another World Radio Conference led to seismic changes infrequency allocation, terrestrial TV broadcasting is turned off (oddly, no-one noticed, as by now everybody is watching HDTV on their home broadband connection if not using their smartphone). Now the full spectrum from 470 to 960 MHz except for the cellular bands becomes available for mobile and other uses provided that the systems use cognitive radio protocols to coexist. After careful consideration the operator decides to use this spectrum to support most of its telematics customers, freeing up its dedicated cellular networks at 800 and 900 MHz to support smartphones. The necessary software is progressively downloaded to all the vehicles that it supports, without their owners or the car maker being aware of any change.

Clearly, bringing wireless connectivity to automotive telematics can provide real benefits for drivers and manufacturers, as well as helping to reduce pollution and making the roads safer. Car makers now have to make their products for a global market, and during the service life of a modern vehicle it may have to communicate over a wide variety of radio networks on a range of frequencies. Defining the radio's functionality in software will allow it to be updated and upgraded throughout its service life.