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Introduction

I often think that we have now finally come full circle in the world of radio transmission. We are back to where it all started: after all, the first transmission via radio waves by Marconi in 1895 was digital, using Morse code.

These days we are heading for a fully digitalized form of radio transmission, often using Internet Protocol (IP). Most radio services – broadcast, voice transmission for mobiles and television transmission – are being digitalized and transmitted via radio waves.

Radio waves – what a discovery that truly has changed our world! The effect of electromagnetism was discovered by H. C. Ørsted in 1820. Samuel E. Morse invented his digital system, the 'Morse code', in 1840. Through copper wires the world got connected via the telegraph line, and cross-continental communication was now accessible. Marconi merged both inventions and created the basis of our modern wireless communication systems, performing the first radio transmission over an incredible distance of 1.5 kilometers in 1895. Now we live in a world totally dependent on spin-offs of these basic discoveries.

Marconi struggled to transmit radio signals over a relative short distance: a few kilometers was a major achievement in the early days. Later, radio waves were used to reach several hundred thousand of kilometers into deep space, communicating with and controlling deep space probes and even vehicles on Mars.

Would it not be fair if we could bring back Ørsted, Morse and Marconi, and honor them by showing what we can do today, using the same principles: electromagnetism, digital transmission and radio waves? I am sure that they and the many other scientists who have formed the basis of our modern communication society would be proud. No one today could even consider a world without easy wireless communication; our modern lifestyle is highly dependent on those small devices – mobile telephones.

Things in telecommunications industry are progressing fast. These days we are not happy with anything less than several Mbps over the radio interface, mobile TV, internet, email and mobile media.

Back in the early 1980s I was working on NMT systems. We used analog modems and were able to achieve up to about 300 baud over the mobile phone network. That was truly amazing at the time. People could send a fax from their car and, if they could carry the 18 kg

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mobile cellular phone battery included, they could have a portable phone with up to 30–60 min of talk time. The cost of these types of cellular phones was equivalent to that of a small family car in the early days, so the market was limited to very few professional users. Over a few years the price dropped to about an average month's salary, and mobile phones were getting smaller and smaller. Some were even 'pocket size' – if your pocket was big and able to support a weight of about 1 kg, that was.

At some point I was told about a new futuristic mobile telephone system in the making called GSM. The plan was to convert the voice to data, and the network could support 9600 baud (9.6 kbps), 32 times more that we could do on NMT! This was an amazingly high data speed – higher than we could get over fixed telephone lines at the time. I remember being highly skeptical. Who would ever need such high data rates for mobile use and for what? Mobile TV? Absolutely mad! Man, was I wrong!

These days we are heading for 14 Mbps via HSDPA, more than 4600 times faster than we could perform via NMT in 1980. In reality, we are now able to handle higher mobile data speed to one user than the total data transmission capacity of the whole NMT network in Denmark could handle then for all the users in the network!

The need for data is endless. Data rates via mobile will increase and increase, and actually the radio link is getting shorter and shorter. In order to perform these high data rates, we need a better and better radio link. The radio spectrum is getting more and more loaded, and we are using higher and higher radiofrequencies and more and more complex and quality-sensitive modulation schemes; thus the requirement for the quality of the radio link is getting more and more strict.

It is worthwhile noting that high data rates are not enough on their own. It is also a matter of services; if mobile users are not motivated by an attractive service, even the highest data rate is pointless.

The need for high data rates is motivated by user demand for mobile email, internet and multimedia services. Most UMTS mobile phones are able to support video calling, but it is rarely used. This shows that, even though it is impressive from a technical viewpoint that it is possible at all, the technology has no point if the service is not attractive to mobile users. It is a fact that the most successful mobile data service to date is also the slowest data service in operation over the mobile network, transmitted via a very slow data channel: SMS (Short Message Service). SMS is still the most popular data service and still the 'cash cow' when it comes to data services for most mobile networks. Who would have thought that mobile users of all ages from 8 to 98 would key in long text messages via a 10 digit keyboard on a mobile phone, when they can pick up the phone and talk? Some users in the network have an SMS activity beyond 2000 SMSs per week!

When I was introduced to SMS, I thought it might be a good service to announce voice mails etc. to mobiles, but when the first mobiles arrived that were able to transmit SMS, my thought was 'why?' Wrong again! It clearly shows that it is not only a matter of data speed but also the value of the applications and services offered to the user.

I am happy to note that one thing stays the same: the radio planning of the mobile networks. The air interfaces and especially the modulation schemes are getting more and more complex, but in reality there is no difference when seen from a basic radio planning perspective. The challenges of planning a high-performance HSPA link is the same basic challenge that Marconi faced performing his first radio transmission. It is still a matter of getting a sufficient margin between the signal and the noise, fulfilling the specific

requirement for the wanted service, from Morse via long waves to 14 Mbps via UMTS/HSPA. It is still radio planning and a matter of signal-to-noise ratio and quality of the link.

In the old days it was all about getting the radio link transmitted over longer and longer distances. These days, however, the radio link between the network and the mobile user is getting shorter and shorter due to the stricter demands on the quality of the radio link in order to perform the high data rates. Marconi struggled to get his radio transmission to reach a mile. These days we are struggling to get a service range from an indoor antenna in a mobile network to service users at 20–40 m distance with high-speed data and good quality voice service.

We are now moving towards an IP-based world, even on the radio interface, and voice-over-IP. We are now using IP connection to base stations and all other elements in the network. The network elements are also moving closer to the mobile users in order to cater for the requirements for quality of voice and data.

We are now on the brink of a whole new era in the world of telecommunications, an era where the mobile communication network will be an integrated part of any building. The telecommunications industry is just about to start integrating small base stations, 'femto cells', in many residential areas in many countries around the world. People expect mobile coverage and impeccable wireless data service everywhere.

When electricity was invented and became popular, existing buildings had to be post-installed with wires and light fixtures to support the modern technology of electrical apparatus and lighting. Later it was realized that electricity probably was so popular that it was worthwhile pre-installing all the wiring and most of the appliances in buildings from the construction phase. I do believe that, within a few years from now, it will be the same with wireless telecommunications. Wireless services in buildings are one of the basic services that we just expect to work from day one, in our home, in tunnels and surely in corporate and public buildings.

The future is wireless.