"If I have seen further, it is by standing on the shoulders of giants" – Sir Isaac Newton (1643 to 1727)

1. Seminal inventions and foundational innovations in 3GPP standards

Some ideas, inventions and technologies are seminal: they are defining capabilities that enable more extensive and higher performing standards. Entirely new standards and additional features in existing standards are enabled by and developed from seminal technologies. For example, cellular code division multiple access (CDMA) communications was made possible by various new technologies conceived around 1990 including "fast power control" and "soft handover." One decade later, a radically new network architecture optimized for mobile broadband data was introduced: this was also based on the CDMA waveform; it was initially called HDR and then renamed EV-DO. The LTE standard was introduced in 2009 with its OFDMA/SC-FDMA waveforms while capitalizing on numerous previous cellular technology developments.

Most recently, Licensed-Assisted Assess (LAA), that exploits unlicensed as well as licensed spectrum, is an innovative new feature in LTE that includes novel concepts and technologies that were developed to aggregate different carriers in previous standards together with technologies specifically conceived to create this new capability. SSO work on LAA commenced following a 2013 workshop presentation on the possibilities by Ericsson and Qualcomm. First commercial deployments were in 2017.

All these and many other foundational technologies in cellular and non-cellular standards were created from significant seminal research and development work by their inventors prior to acceptance, even for study, by cellular standard-setting organization (SSO) 3GPP. These capabilities were developed in collaboration with many other companies prior to full adoption by the SSO in Work Items, followed by standardization and then commercialization in devices and networks.

Many companies commit a lot of time and effort to development of new features and standards, however:

a) Only a small proportion of SSO contributions (e.g. right from presentation of initial concepts in SSO workshops) – including those with technologies declared as possibly standard-essential – are seminal.
b) Only a small number of (mostly major) companies tend to develop, contribute, patent and declare these seminal technologies as essential to the standards.

Seminal contributions and technologies are most valuable. Many more SSO contributions, followed by patent-essentiality declarations, are made as standards are then set in the SSO based on the seminal contributions. Contributions to SSO 3GPP (and SEP declarations to the ETSI IPR database) also show a rather larger number of companies participating once the new technology begins to be adopted (e.g. as a 3GPP Study Item and then as a Work Item and then written-in to the latest standard). This can inflate the total number of contributions and patent declarations later with inclusion of lower-quality and lower-value inputs.

Seminal technologies are built upon with other technologies to complete features and standards. Seminal technologies are also adopted among various features and standards – including later standards in the same SSO and standards developed by other SSOs.

New features and standards have also been significantly and cumulatively founded on what has already been developed elsewhere including seminal inventions and the foundational technologies they have enabled:

1. Cellular CDMA technologies – including the seminal technologies for power control and soft handover identified above – first appeared in 2G cdmaOne, and then subsequently in 3GPP2 CDMA2000 and 3GPP WCDMA.
2. MIMO – appeared in HSPA and then in LTE
3. Carrier Aggregation – first appeared in EV-DO Rev B, then in DC-HSPA and then in LTE-Advanced with the first commercial services for the latter commencing 2013.
4. LAA also relies significantly on prior development work and standardisation in carrier aggregation.

2. Follow-on innovations on top of technology standards

Cellular technologies are vital to much of the utility and value that consumers derive from non-cellular technologies. Cellular technology advances facilitate development of the downstream smartphone ecosystem. For example, built-in cameras would be worth much less to the user without the ability to immediately transmit photographs or live video (whether by email, text, or social media). GPS capability would be worth much less without the ability to rapidly download maps and other location-dependent data. High-resolution color screens would be worth much less without the capability to receive downloads or data streams adequate to fill those screens with photographs or video.

Smartphone software applications now used globally by large numbers of consumers include Google, YouTube, Facebook, Twitter, Instagram, and Snapchat, and popular Chinese examples including Baidu, Youku Tudou, Sina Weibo, and TenCent's WeChat. These applications and the operating system software, including Android or iOS, on which they run, would be far less useful, if useful at all, without high data-rate cellular connections that provide a wide-range of immediate, on-the-go communication and content options, particularly as compared to devices that have only Wi-Fi connections or no wireless connectivity at all.

A fast, reliable and secure cellular data connection is necessary to enable the full functionality that consumers demand and now take for granted. Nowhere near as much follow-on innovation for smartphones would continue to occur if the cellular data rates remained stagnant. Data speeds have increased 10,000-fold over the last 20 years with more than 1 Gbps possible today. Seminal technologies being developed right now for 5G will make possible cellular communications at centimetre and millimetre radio wavelengths. This will enable extremely-high data rate new follow-on applications demanding several gigabits per second.

Other improvements such as reduced latency and lower power consumption are also being exploited to improve the performance of existing follow-on applications and enable entirely new applications that were not previously possible. For example, low latency makes possible highly interactive virtual-reality games.

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Keith Mallinson is founder of WiseHarbor, providing expert commercial consultancy since 2007 to technology and service businesses in wired and wireless telecommunications, media and entertainment serving consumer and professional markets. He is an industry expert and consultant with 25 years of experience and extensive knowledge of the ICT industries and markets, including the IP-rich 2G/3G/4G mobile communications sector. His clients include several major companies in ICT. He is often engaged as a testifying expert witness in patent licensing agreement disputes and in other litigation including asset valuations, damages assessments and in antitrust cases. He is also a regular columnist with RCR Wireless and IP Finance – “where money issues meet intellectual property rights.”

The author can be contacted at WiseHarbor. His email address is kmallinson@wiseharbor.com and you can also follow him on Twitter at http://twitter.com/WiseHarbor.