White paper

Long Term HSPA Evolution
Mobile broadband evolution beyond 3GPP Release 10

Nokia Siemens Networks

HSPA has transformed mobile networks

Contents

Mobile broadband data has proved to be a successful offering that has attracted a large number of users enjoying high-quality data services via laptops, notebooks and smartphones. In many advanced HSPA markets, the data volume is more than ten times that of voice in terms of transferred gigabytes.

HSPA has transformed mobile networks from being voice-dominated to data-dominated in just a few years. It has been deployed in more than 150 countries by more than 350 communications service providers (CSP) on multiple frequency bands and is now the most extensively sold radio technology globally.

HSPA will continue to be deployed in parallel with the introduction of LTE. The need for higher data rates and volume growth continues to drive advances in radio technology. Many of the same performance-boosting innovations can be applied to both HSPA and LTE. The evolution of HSPA beyond Release 10 in 3GPP shows no signs of slowing. In this paper, the term Long Term HSPA Evolution is used to refer to HSPA features introduced in 3GPP beyond Release 10.

Multicarrier and multiband HSPA aggregation

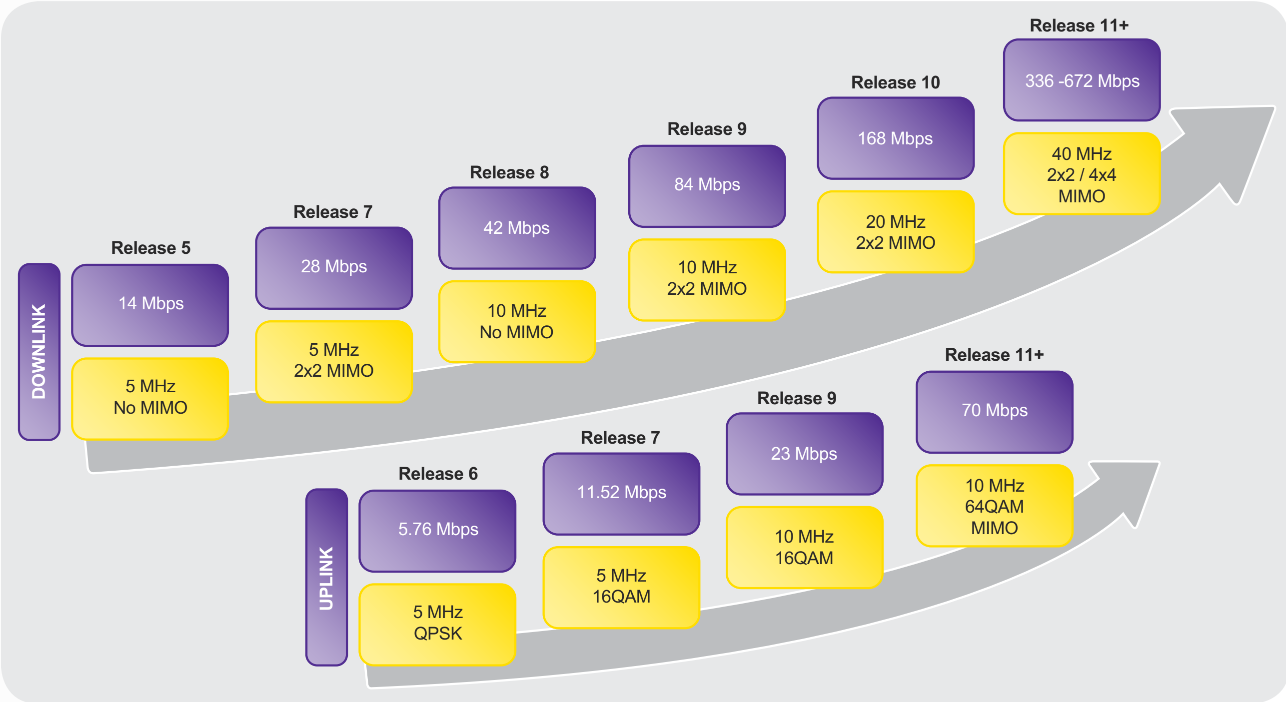

Figure 1. Projected HSPA peak data rate evolution with increased bandwidth and number of antennae.

HSPA Release 10 with 4-carrier HSDPA provides a peak downlink data rate of 168 Mbps using 2x2 MIMO (Multiple Input Multiple Output) over the 20 MHz bandwidth. This matches the LTE Release 8 data rates obtained using comparable antenna and bandwidth configurations. A natural next step for the HSPA Release 10 downlink is to further extend the supportable bandwidths to 40 MHz with 8-carrier HSDPA, doubling the Release 10 peak rate to 336 Mbps. 8-carrier HSDPA coupled with 4x4 MIMO doubles the peak rate again to reach 672 Mbps, see Figure 1. The evolution of HSPA beyond Release 10 will push the peak data rates to rival those provided by LTE Advanced.

In addition to increased peak rates, the aggregation of a larger number of carriers improves spectrum utilization and system capacity owing to inherent load balancing between carriers. Additional capacity gains from trunking and frequency domain scheduling will also be seen.

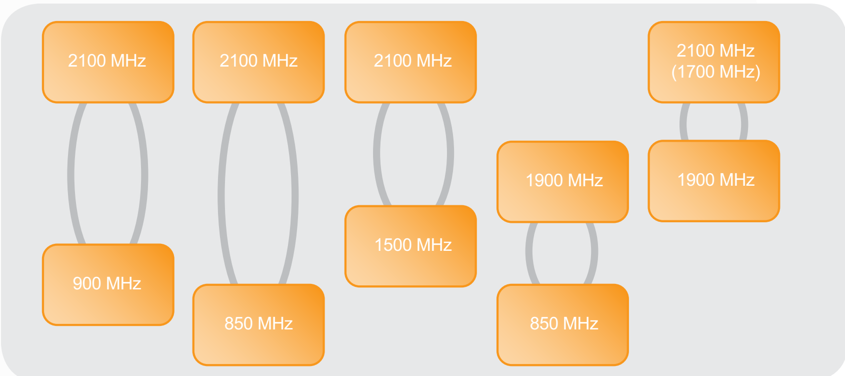

Figure 2. HSDPA multiband combinations.

Typical spectrum allocations do not provide 40 MHz of contiguous spectrum. To overcome spectrum fragmentation, HSDPA carrier aggregation allows carriers from more than one frequency band to be combined. 3GPP Release 9 already makes it possible to achieve 10 MHz allocation by combining two 5 MHz carriers from different frequency bands, such as one carrier on 2100 MHz and another on 900 MHz. The 4-carrier HSDPA of Release 10 extends this further, allowing the aggregation of up to four carriers from two separate frequency bands. Long Term HSPA Evolution allows eight carriers. Typical cases of HSDPA multiband aggregation are shown in Figure 2.

HSPA and LTE carrier aggregation

The idea of aggregating multiple carriers to increase performance is included in both LTE and HSPA. A logical step to fully leverage existing HSPA deployments and future LTE deployments is to aggregate the capacity of both systems and tie them together into a single mobile system. The concept is illustrated in Figure 3.

The aggregation of LTE and HSPA systems enables the peak data rates of the two systems to be added together. It also allows for optimal dynamic load balancing between the two radios. A small number of active LTE and HSPA aggregation-capable devices is sufficient to exploit this load balancing gain, since the network can schedule these devices to carry more data on the radio that has lower instantaneous loading and less data on the radio with the higher load at any given moment.

The Nokia Siemens Networks Flexi Multiradio Base Station is ideal for LTE and HSPA aggregation thanks to its unique software-defined radio capability, which supports both systems using the same hardware. The overview is shown in Figure 4. Carrier aggregation is expected to have no impact on the core network.

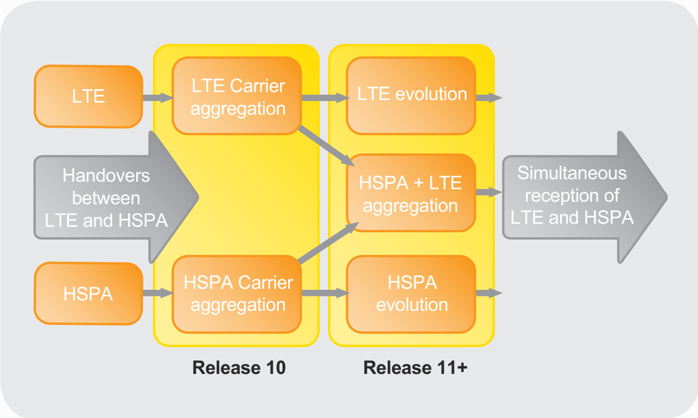

Figure 3. Carrier aggregation paths for LTE and HSPA in 3GPP standards.

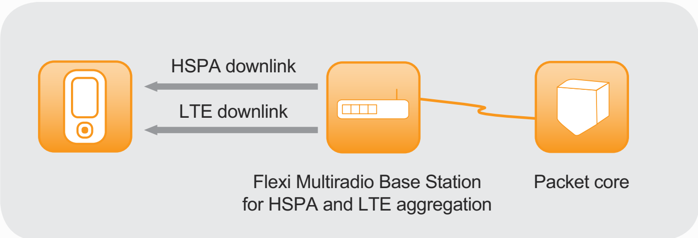

Figure 4. HSPA and LTE carrier aggregation.

HSDPA multipoint transmission

Cell edge data rates are a challenge in all systems experiencing high system loads. This is because of inter-cell interference experienced by mobile devices at the cell edge. Improving data rates at the cell edge provides a fairer distribution of the data rates over the whole cell area. 3G systems already include the concept of soft handover for WCDMA-dedicated channels, as well as for HSUPA. But so far HSDPA data can only be received from one cell at a time. 3GPP Release 11 seeks to improve the downlink cell edge performance using multipoint transmission. The concept is illustrated in Figure 5.

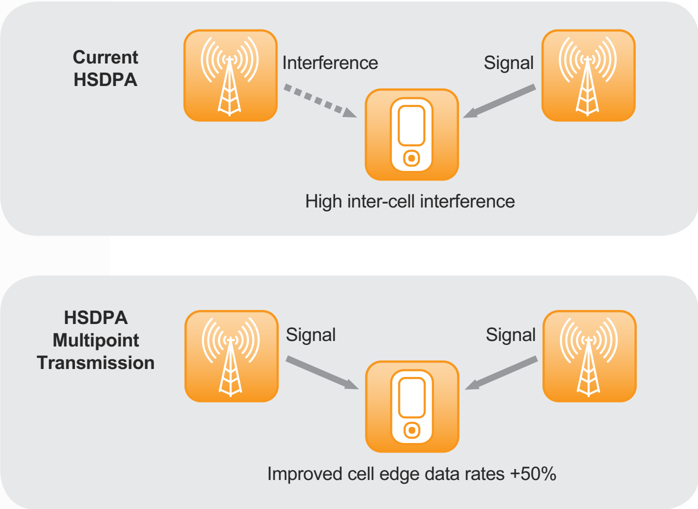

Figure 5. HSDPA multipoint transmission.

HSDPA Multipoint Transmission combats inter-cell interference in two ways. First, the received signal energy is increased for mobiles at the cell edge by transmitting from both the serving and the neighbor cell. Second, the received interference level is significantly decreased since the dominant interferer is eliminated when the neighbor cell is not transmitting a competing signal to some other mobile and thus does not interfere with the desired signal from the serving cell.

HSDPA Multipoint Transmission can use the RNC – an existing centralized radio network element – to optimize the flow of backhaul data for multipoint transmission.

Multi-antenna MIMO evolution

A multi-antenna solution with 2x2 MIMO has already been deployed in the downlink in commercial HSDPA networks. The next step is to push the multi-antenna transmission to 4x4 MIMO, which can double the peak data rate and also improve the typical cell capacity and user data rates. Another potential development in the downlink is Multiuser MIMO, where parallel data streams can be transmitted to different mobiles to increase the cell capacity. Uplink 2x2 MIMO is also being considered for the evolution of HSPA. MIMO evolution topics are illustrated in Figure 6. Nokia Siemens Networks has extensive experience with advanced antenna solutions, with a large number of 6-sector and 2x2 MIMO deployments in commercial networks and with multiple active antenna trials.

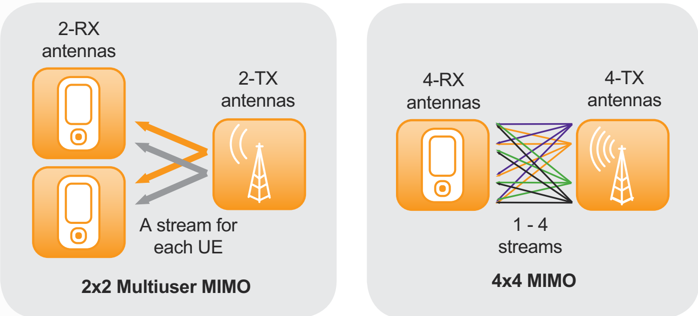

Figure 6. HSDPA MIMO evolution.

Uplink dual antenna transmission

Uplink dual antenna transmission will provide better data rate coverage and lower neighbor cell interference by beamforming. It will also double the peak uplink rate using dual stream transmission. In an approach that's analogous to the downlink MIMO, the mobile device uses two transmit paths and antennas to form a complex radio wave pattern in the multiple base station receive antennas. In favorable radio conditions this yields over 2 dB in the link budget, which translates to up to 30% higher average uplink data rates throughout the cell and up to 40% higher data rates at the cell edge. In another analogy to downlink MIMO, in very good channel conditions and when a high received signal-to-noise ratio is possible, the user equipment may use dual stream MIMO transmission with two orthogonal beam patterns. This effectively doubles the raw bit rate on the physical layer.

In order to be able to reach received signal-to-noise ratios that are high enough to make dual stream transmission possible, clear dominance areas, four receiver antennas, or a combination of both will be required. Yet again this is analogous to what happens in the downlink. Dual antenna transmission in the uplink should be viewed as two separate features. First there's the uplink beamforming, which is possible and beneficial in most environments and provides better uplink data rate coverage. Second is the uplink dual stream MIMO, which is possible only in more limited scenarios and doubles the uplink peak rate.

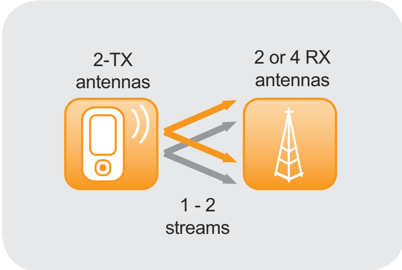

Figure 7. Uplink dual antenna transmission for HSUPA.

Self Organizing Networks

The explosion of data traffic combined with more base stations on multiple frequency bands presents new challenges in network optimization. The target in a Self Organizing Network (SON) is to simplify network operability to provide sustainable operational costs and better end-user performance. Automatic Neighbor Relations is a good example of a SON feature, where the network can configure the neighbor lists automatically based on mobile measurements. The functionality is illustrated in Figure 8.

Minimization of drive testing is another example, where the aim is to enhance measurement collection and reporting by mobile devices in order to substitute the information for data collected in traditional drive testing. Avoiding drive tests is beneficial both in terms of costs and CO_2 emissions.

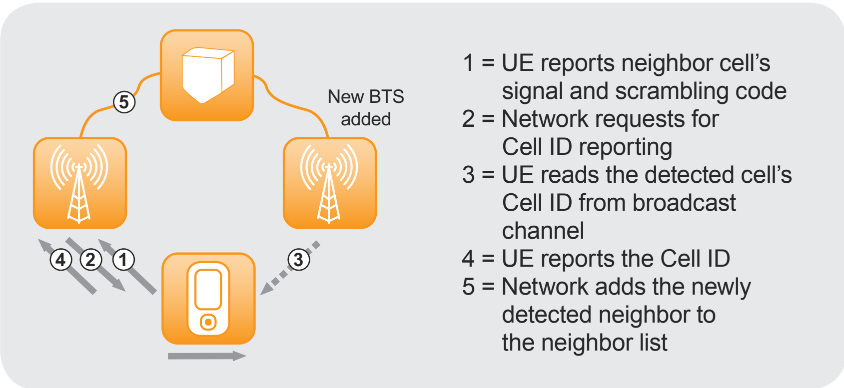

Figure 8. Automatic neighbor cell relations in HSPA.

3GPP status of Long Term HSPA Evolution

The 3GPP RAN Plenary session on 7-10 December 2010 initiated the technical work and study items on the following features for Long Term HSPA Evolution Beyond 3GPP Release 10:

- HSDPA Multicarriers by combining up to eight carriers.
- Dual antenna beamforming and MIMO in uplink.
- HSDPA Multipoint transmission.

The detailed specification work to deliver these features will take place in RAN working groups. Other HSPA Evolution features are expected to be considered in subsequent 3GPP meetings.

Summary

The evolution of HSPA will continue in parallel with work on LTE Advanced. All Long Term HSPA Evolution features are backwards-compatible and can be used together with existing WCDMA and HSPA mobile devices on the same carriers, including circuit-switched voice support. The new features can push peak data rates to 672 Mbps, increase cell capacity, improve cell edge data rates and simplify network operability

Nokia Siemens Networks leads the way in HSPA, and demonstrated data rates exceeding 100 Mbps during Mobile World Congress in Barcelona in early 2010. Nokia Siemens Networks is committed to serving its almost 200 WCDMA/HSPA customers and providing them with leading radio network solutions that can migrate smoothly to future technologies like Long Term HSPA Evolution, with platforms such as Flexi Multiradio Base Station and Multicontroller RNC.

Abbreviations

3GPP	3G Partnership Project
HSPA	High Speed Packet Access
ID	Identity
IP	Internet Protocol
LTE	Long Term Evolution
MIMO	Multiple Input Multiple Output
SON	Self Organizing Networks
UE	User Equipment

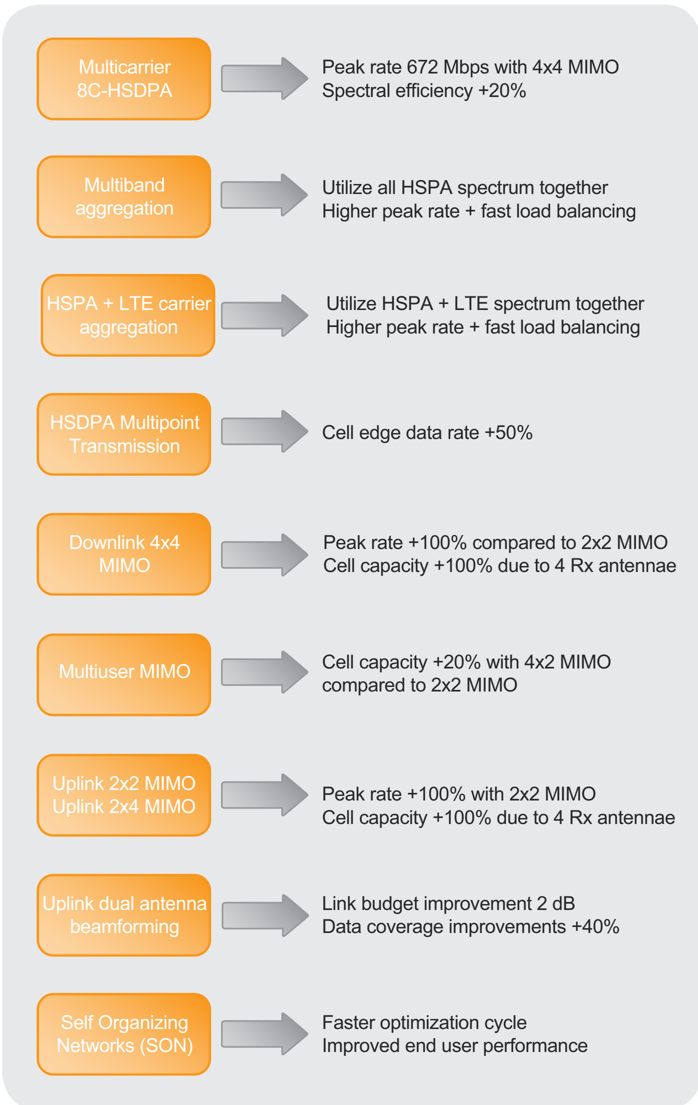

Figure 9. Summary of main Long Term HSPA Evolution Features.

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