High Capacity Mobile Broadband for Mass Events
## Contents

1. Introduction ........................................ 3
2. Traffic Profiles in Mass Events .................. 4
3. Liquid Radio Software Suites: HSPA+ Enhancements 5
4. LTE Requirements ................................ 7
5. RF Planning and Optimization .................... 8
6. Distributed Antenna System (DAS) ............ 9
7. Small Cells .......................................... 11
8. Smart Wi-Fi Capacity .............................. 12
9. Enhanced Multimedia Broadcast Multicast Services (eMBMS) 13
10. Summary .......................................... 14
11. Abbreviations ................................... 15
1. Introduction

The popularity of smartphones creates huge capacity requirements for networks during mass events in stadiums housing up to 100,000 people or across larger urban areas with up to a million or more participants. At such events, large numbers of people use their smartphones to share pictures and experiences and download information. This behavior creates traffic profiles that differ from those typically seen in the network, with higher uplink traffic and more frequent packet transmission.

Planning for these events must consider the uplink capacity and control plane dimensioning. Network RF planning in large open areas creates further challenges in terms of inter-cell interference.

These challenges and the Nokia Networks solutions are discussed in this white paper.

Nokia Networks is experienced in providing high capacity solutions in mass events. Recent examples include more than 25 Gigabytes of data per hour during a huge sports event in the UK, more than 150 Gigabytes of data per hour in a Korean fireworks festival, and more than 100 Terabytes of data during the 6-day Hajj pilgrimage. In all cases, excellent end user performance was achieved.

Figure 1. Example mass events
2. Traffic Profiles in Mass Events

Traffic profiles in mobile networks are usually dominated by downlink traffic, which is up to ten times greater than uplink traffic volumes. Downlink traffic is created mainly by streaming traffic from smartphones, laptops and tablets.

The traffic profile during mass events, however, tends to be different:

- Relatively higher uplink traffic is created by participants sharing pictures from the event, for example in Facebook. The uplink can even experience more traffic than is seen in the downlink. Streaming is not typically used during mass events unless there are venue specific services, like a replay video service to show goals or touchdowns. Figure 2 shows the potential asymmetry.

- The average data volume per channel allocation is smaller in mass events because the traffic is generated by smartphones instead of laptops or tablets. Figure 3 shows an example data volume per channel allocation. Each channel allocation also consists of several smaller packets with average sizes of just 120 bytes in the uplink and 840 bytes in the downlink as measured in live networks.

![Figure 2. Traffic asymmetry between downlink and uplink](image1)

![Figure 3. Data volume per channel allocation](image2)
3. Liquid Radio Software Suites: HSPA+ Enhancements

HSPA+ has turned out to be the most successful and widespread mobile broadband solution globally. HSPA+ offers attractive end user data rates, high spectral efficiency for data and good voice capacity in live networks.

However, mass events still require special attention for optimized performance. During an event, HSPA+ performance can be limited by interference from Random Access Channel (RACH) and from Dedicated Physical Control Channel (DPCCH) in both the uplink and downlink. The transmission time of the user data is just a few milliseconds for small packet sizes, while DPCCH runs for a few seconds, see Nokia Networks White paper “HSPA+ Boosters for Multifold Performance”.

The main solutions for minimizing uplink interference are Nokia Mass Event Handler (MEH), and Nokia Liquid Radio Software Suites offering features such as Continuous Packet Connectivity (CPC), High Speed RACH (HS-RACH), 4-branch uplink reception (4RX) and Interference Cancellation (IC).

The benefits of these solutions include:

- MEH: dynamic adjustment of cell level parameters when congestion is identified
- CPC: discontinuous DPCCH transmission
- HS-RACH: more efficient common channel transmission without dedicated channel allocation
- 4RX: 3 dB lower terminal transmission power
- IC: cancellation of intra-cell interference
Combining all these solutions yields a huge improvement in uplink capacity for small packet transmission. Figure 4 illustrates that the capacity can be enhanced by 50 to 75 times.

The main solutions for minimizing downlink interference are:

- Fractional DPCH (F-DPCH) which removes the need for any Release 99 channel to therefore avoid downlink DPCCH
- HS-FACH, which is the same as HS-RACH but for the downlink
- Mass Event Handler (MEH) which dynamically allows more power to be used for Release 99 channels if required and therefore avoids repetitive attempts and rejections for Release 99 high priority services such as voice.

All these HSPA+ improvements are available commercially in networks and in devices (where support is needed) during 2013.
4. **LTE Requirements**

Being packet-based, Long Term Evolution (LTE) is inherently well suited to the bursty transmission of small packets, although challenges still exist during extreme mass events, such as control plane processing capacity, RACH capacity and inter-cell interference.

Figure 5 shows an example live network with highly loaded LTE base stations. The network experiences up to 60 handovers per second, up to 50 EUTRAN Radio Access Bearer (eRAB) setups per second, and up to 40 Radio Resource Control (RRC) setups per second. The total number of allocations over the hour exceeds 200,000 per base station. Such high signalling frequency requires high control plane capacity in the base station. Nokia Flexi Base Station is designed for high capacity in the control and user planes.

Physical layer Random Access Channel (PRACH) collisions can occur in 3G and LTE. If two terminals select the same PRACH resource, unnecessarily high power is needed for the Physical Uplink Shared Channel (PUSCH), which causes massive inter-cell interference. PRACH capacity allocation and expected PRACH traffic and capacity requests on PRACH must be managed properly to avoid collisions.

![Control plane actions per base station per second](networks.nokia.com)
5. RF Planning and Optimization

The mass event capacity depends heavily on the number of cells and on network RF planning. More cells can, in theory, provide more capacity, but if cell overlapping increases, the additional cells may only increase interference levels. Therefore, the cell dominance areas need to be planned carefully to avoid unnecessary cell overlapping.

Practical solutions include selection of antenna locations and selection of antenna downtilts. However, physical antenna locations may be limited in mass events, so an active antenna, such as the Nokia Flexi Multiradio Antenna System, can be used to bring flexibility to beam steering. The active antenna includes small RF elements inside the antenna which makes the site solution compact and brings flexible beamforming capability. Figure 6 shows the active antenna concept.

Figure 6. Active antenna for vertical sectorization
6. Distributed Antenna System (DAS)

DAS is becoming an increasing popular way to address both the coverage and the capacity needs of mass events.

The DAS infrastructure is typically part of the venue and is provided by the venue’s owner. It is able to host multiple wireless operators who pay a fee. It is also able to host multiple technologies.

An operator uses the DAS by attaching its RF Head antenna ports to the DAS node as shown in Figure 7. The DAS Net Aggregator combines multiple operators and RATs through a mixed active/passive network that provides analog to fiber conversion and distribution within DAS equipment. Figure 8 shows a typical stadium with 12 LTE and WCDMA cells each with six antennas (two in each tier.) The antenna sites are shown as triangles and round dots are user positions, while the other colors denote the first cell attachment. The subsequent plot is the user Carrier to Interference Noise Ratio (CINR) where the DAS antenna locations become visible.

Figure 7. Distributed Antenna System
Figure 8. Stadium with 12 cells each with six antennas
7. Small Cells

Mass event capacity can be raised efficiently by micro and pico base stations. Although pico base stations are small, they do provide high capacity to support mass events (allowing hundreds of users to be connected to a single base station), and are available for outdoor and public-space deployment. This contrasts with enterprise femto access points, for example, which are designed for enterprise use cases, both from environmental aspects, but also from a capacity point of view.

Pico base stations should be designed around feature parity to macro cells to deliver consistent end user performance across different cells and in order to make network optimization and interference management simple between macro and small cells. The pico base station’s small size and light weight reduces site and infrastructure requirements significantly, and its large capacity makes it the right choice for handling mass event capacity.

Small base stations are also visually discrete and can be camouflaged easily to blend with the surrounding environment, making them virtually unnoticeable as a base station. An example small cell product is shown in Figure 9: Nokia Flexi Lite Base Station with a volume of 10 liters and weight of 10 kilograms, offering output power of 10 watts for WCDMA/HSPA.

Figure 10 shows a Nokia Flexi Zone Micro Base Station with LTE capability, and which has a size of only 5 liters and weighs just 5 kilograms, but offers an output power of 5 watts. Meanwhile, the Nokia Flexi Zone Pico Base Station with 1 watt output power and optional Wi-Fi could form the base of a very dense deployment in mass event locations by combining the capacity of LTE and Wi-Fi with a very closely spaced deployment grid.

Flexi Zone enables hot spots to be evolved into a hot zone covered by a cluster of small LTE base stations connected to a local controller, for serving highest capacity requirements. Flexi Zone also minimizes the backhaul load, optimizes radio resource management and simplifies network operation. For more details, see http://www.nsn.com/sites/default/files/document/flexizone_brochure_120124.pdf.
8. Smart Wi-Fi Capacity

To meet growing demand for additional capacity and data services, Wi-Fi is used increasingly as a cost effective means to add capacity and to complement available mobile networks. Wi-Fi has become a standard feature in smartphones and tablets, providing mass event organizers with an opportunity to take advantage of this unlicensed spectrum to improve the user experience and offer venue-specific applications. The recently launched Nokia Smart Wi-Fi is an end-to-end solution for building, optimizing and controlling Wi-Fi networks.

The overwhelming number of users and business critical applications, like ticketing, can introduce a significant stress on the available Wi-Fi network, requiring careful Wi-Fi network planning. Use of the 5 GHz band provides wider frequency spectrum and more bandwidth, as well as a higher number of available channels, allowing more Access Points (APs) to be deployed to meet the capacity demand without interference. The 2.4 GHz band will also need to be supported and because the band has three non-overlapping channels (1, 6, 11), reusing those channels is the primary alternative.

As most devices in a mass event are expected to be smartphones supporting 3G/LTE and Wi-Fi accesses, the use of all available networks should be considered for achieving the best overall user experience. The Smart Wi-Fi solution integrates mobile and Wi-Fi networks for a seamless experience by supporting 3G like usability and security for Wi-Fi access and harmonizing traffic handling across mobile and Wi-Fi networks.

In addition, Smart Wi-Fi balances traffic across available mobile and Wi-Fi networks by controlling when and where user devices utilize mobile and Wi-Fi networks according to the operator’s business strategy.

Figure 11. Nokia Smart Wi-Fi solution turns Wi-Fi networks into seamless extensions of the mobile network
9. Enhanced Multimedia Broadcast Multicast Services (eMBMS)

Enhanced Multimedia Broadcast Multicast Services (eMBMS) use the LTE network to send the same content simultaneously to all users in the cell coverage area. eMBMS is well suited to the delivery of video or other content during a mass event because many participants would like to see the same content from game or event. The cell’s resources can be adjusted dynamically between eMBMS and point-to-point transmission depending on the instantaneous requirements, which allows quick adaptation to the different mass event cases.

The introduction of eMBMS carries some challenges. First, eMBMS support is required in the terminals. Current terminals do not support eMBMS and it will take some time before good penetration is achieved. Secondly eMBMS as a broadcast/multicast technology does not address challenges from increasing uplink capacity requirement - which specifically in mass events must be addressed (e.g. Facebook users sharing content). As a third and generally applicable consideration, eMBMS is hardly useful outside mass events since most people want to see video-on-demand content rather than linear TV broadcast content. Therefore, the eMBMS application area may be too limited in the short term in current spectrum allocations. If more UHF spectrum could be used for eMBMS and if terrestrial TV was delivered over eMBMS, the application areas would be more attractive.

Figure 12. Dynamic sharing of resources between eMBMS and point-to-point
10. Summary

Mass events set high requirements on mobile networks. A large number of users in a small area, relatively more uplink traffic, high transmission frequency of small packets combined with challenging RF planning. Nokia Networks radio networks have shown very good performance in mass events and there are further solutions available in 3G and in LTE to increase the capacity - even up to 75x in 3G.

Nokia Networks is pushing the limits further with active antennas and efficient use of distributed antenna systems. Micro and pico base stations can be used efficiently to provide high capacity with simple installation, and enhanced later to a Flexi Zone deployment. Additionally, cellular network capacity is complemented by Wi-Fi offloading with the introduction of reliable and high Wi-Fi RF performance with integration of mobile and Wi-Fi networks for the best possible user experience.
### 11. Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3GPP</td>
<td>Third Generation Partnership Project</td>
</tr>
<tr>
<td>CINR</td>
<td>Carrier to Interference Noise Ratio</td>
</tr>
<tr>
<td>CPC</td>
<td>Continuous Packet Connectivity</td>
</tr>
<tr>
<td>DAS</td>
<td>Distributed Antenna System</td>
</tr>
<tr>
<td>DPCCH</td>
<td>Dedicated Physical Control Channel</td>
</tr>
<tr>
<td>eMBMS</td>
<td>Enhanced Multimedia Broadcast Multicast Services</td>
</tr>
<tr>
<td>eRAB</td>
<td>EUTRAN Radio Access Bearers</td>
</tr>
<tr>
<td>F-DPCH</td>
<td>Fractional DPCH</td>
</tr>
<tr>
<td>HSPA</td>
<td>High Speed Packet Access</td>
</tr>
<tr>
<td>HS-FACH</td>
<td>High Speed Forward Access Channel</td>
</tr>
<tr>
<td>HS-RACH</td>
<td>High Speed RACH</td>
</tr>
<tr>
<td>IC</td>
<td>Interference Cancellation</td>
</tr>
<tr>
<td>LTE</td>
<td>Long Term Evolution</td>
</tr>
<tr>
<td>MEH</td>
<td>Mass Event Handler</td>
</tr>
<tr>
<td>PRACH</td>
<td>Physical layer Random Access Channel</td>
</tr>
<tr>
<td>PUSCH</td>
<td>Physical Uplink Shared Channel</td>
</tr>
<tr>
<td>RACH</td>
<td>Random Access Channel</td>
</tr>
<tr>
<td>RAN</td>
<td>Radio Access Network</td>
</tr>
<tr>
<td>RF</td>
<td>Radio Frequency</td>
</tr>
<tr>
<td>RRC</td>
<td>Radio Resource Control</td>
</tr>
<tr>
<td>WLAN</td>
<td>Wireless Local Area Network</td>
</tr>
</tbody>
</table>