The Mobile Revolution

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Global mobile business context

- More than 1.4 billion people, or 20% of the global population, have a mobile phone, and more than 75% are GSM customers.
- 2 billion people in the world have yet to make a phone call - when it happens it will most likely be on a mobile phone not a fixed line.
- Increasing proportion of revenue from non-voice
  - now over 17% for Vodafone globally 2004/5.
The beginning

- In the 1970’s Bell Labs developed the Advanced Mobile Phone Standard (AMPS) that initiated the Cellular revolution.
- In the 1980’s Nordic Mobile Telephone standard was deployed in the Scandinavian countries.
- In the mid 1980’s, UK Total Access Communications System was developed based on AMPS.
- The following slides will take us through the revolution from 1985 to present.
How mobile phones have developed

1985

1st “transportable” Phone

1st January
Vodafone UK network starts
How mobile phones have developed

1986

Nokia “Talkman”
Weight - 4.8 Kg
Price - £3000
How mobile phones have developed

1987

Siemens C2
“Transportable”
How mobile phones have developed

1989

Motorola MicroTAC personal cellular phone. The phone retails for an estimated $3000
How mobile phones have developed

1st GSM mobile phone

1992

Motorola International 3200

(>500g)
How mobile phones have developed

1993

Panasonic I series
How mobile phones have developed

1994

Vodafone UK Digital data fax and short text messaging services

Nokia 2140
How mobile phones have developed

1995

Bosch M-cam

1st sub 200g mobile phone
How mobile phones have developed

1996

1st PDA mobile phone

Nokia 9000 communicator
How mobile phones have developed

1997 1st Colour display

Siemens S10
How mobile phones have developed

1st Dual-band mobile phone

1998

Siemens S15E
How mobile phones have developed

1999

1st WAP capable mobile phone

Nokia 7110
How mobile phones have developed

1st mobile phone to play MP3 files

2000

Samsung SGH-100
How mobile phones have developed

2001

1st 3G voice call - Vodafone & Ericsson
1st Active colour display – SonyEricsson T68
1st Bluetooth phone – Ericsson T39m
1st Polyphonic ring tones – Sony Z7
1st Integral FM radio – Nokia 8310
How mobile phones have developed

1st Camera Phone
1st “Smart Phone”

2002

Nokia 7650
XDA
How mobile phones have developed

2003

1st Vodafone 3G data card
1st Video recording phone – Nokia 3650
1st Dedicated game phone – Nokia N-Gage
1st Rotating screen – Samsung SGH-P400
How mobile phones have developed

Vodafone launch 3G networks in 13 countries

1st Two mega pixel camera phone with optical zoom – Sharp 902

2004
How mobile phones have developed

2005

3G Video Calling, Internet browsing, Full Track Music downloads, Location based Services, High Speed Data Access
How mobile phones have developed

- Mobile data access
  - Text message
  - FAX
  - WAP
  - Voice call

- Wireless device connectivity
  - Increased data rate
  - Picture message
  - Video games
  - Video playback
  - Instant Email access
  - Fast Internet browsing
  - Video telephony
  - High Speed Data Access
  - Full Track Music downloads
  - Location based Services
Looking forward - new ways of displaying content

**Today**
- LCD display resolution progressing towards VGA (640x480 pixels)
  - as good as the eye can resolve at typical viewing distances…
  - …and capable of supporting DVD-quality
  - …but user experience degraded by small display size

**Tomorrow**
- Organic LED will improve image quality
- 3D displays will compensate for small physical display size by adding depth
- But ultimately the need will be for larger displays that fill the field of view and support multiple viewing windows:
  - Head-up displays (high-definition resolution)
  - Micro-projectors
  - Pull-out displays (flexible/rollable)
Looking forward - a multiplicity of local connectivity

Today
- InfraRed
- Bluetooth
- Memory cards
- USB

Tomorrow
- All of the above with the addition of:
  - Near Field Communications
    - device pairing & local network configuration
    - service discovery/initiation
  - WLAN (802.11b)
    - Home and office connectivity
    - Wireless extension of DSL in the home
    - For both charging and synching content to the terminal
  - UWB
    - Wireless USB
Mobile TV - *bmco* trials in Berlin

**World’s first trial** of MobileTV with interactive services

- DVB-H/GSM terminals
- friendly user group
- proved technical feasibility and user demand/interest
- insight into the nature of successful services
Multimedia device – © 2009

**Display**
- DVD quality (VGA)

**DVB-H**
- Broadcast reception

**Processor**
- DVD quality video (H.264 decode)
- Support for a range of audio and video codecs
- Support for PS2-quality games

**Removable storage**
- 128 MB <<<< 16 GB

**Hard DD Storage**
- 2 GB <<<<< 50 GB

**Embedded Flash**
- 6 MB <<<< 128 MB
Part of Life

_Health care use_

- Diabetes monitoring trial at Oxford University
- Health monitoring trial for people with heart & lung problems in Spain
- Monitoring health of AIDS patients in South Africa

_Peace of mind_

- Personal security for vulnerable
- Controlled freedom for the young
- Access to emergency services

The Foundations
Investing in communities and the environment
The need for base stations

Coverage
- The local base station is the radio access to the network

Capacity
- Each base station has capacity limited by spectrum bandwidth
- Spectrum is limited and needs to be re-used across network
  - Interference from such re-use is a critical network design factor

Capability
- There are physical limits to how far and how fast you can transmit a bit
Drivers for site density

Portable terminals = more sites

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Site density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rooftop panel (10dBi)</td>
<td>1</td>
</tr>
<tr>
<td>Upstairs window, fixed (3dBi)</td>
<td>12</td>
</tr>
<tr>
<td>Outdoor laptop (0dBi)</td>
<td>60</td>
</tr>
<tr>
<td>Indoor laptop (0dBi) Suburban</td>
<td>230</td>
</tr>
<tr>
<td>Indoor laptop (0dBi) Urban</td>
<td>800</td>
</tr>
</tbody>
</table>

Faster data = more sites

3 Sector base station at 25m to outdoor PC card

<table>
<thead>
<tr>
<th>Data Rate</th>
<th>Site density</th>
</tr>
</thead>
<tbody>
<tr>
<td>100Mb/s</td>
<td>50</td>
</tr>
<tr>
<td>10Mb/s</td>
<td>15</td>
</tr>
<tr>
<td>1Mb/s</td>
<td>3.6</td>
</tr>
<tr>
<td>100kb/s</td>
<td>1</td>
</tr>
</tbody>
</table>

Range

Higher frequencies = more sites

900MHz
2100MHz
2500MHz
3500MHz
4000MHz
The effect of frequency
Factors affecting transmit power – GSM cell site

- Max power per transmitter (100mW < ~10W)
  - depends on coverage needed.

- Number of installed transmitters (2 < ~10)
  - designed to limit congestion <2%

- One frequency per cell transmits all the time at max power
  - Broadcast Control Channel – but using only 2 of the 8 time slots

- Other frequencies are used to provide the timeslots needed to support calls at that time (“traffic”), at the power level needed for call (“power control”) and when speaking (or sending data) to the user (“discontinuous transmission”)

- Even at busiest time of day not all frequencies are in use – and those that are in use do not all operate at full power or continuously
Impact on actual transmit power

- Even without power control & discontinuous transmission, the peak power output at busiest time is below the theoretical maximum for cell

- Power control & DTX are each likely to limit power to 50-70%

- For a 6 transceiver cell, maximum power output in busy hour is likely to be 30% to 50% maximum power
Measured transmit power

- In any hour, the maximum number of active timeslots noted and % of max available determined

- Effect of Power control & DTX each 50-70% max. per controlled timeslot.

- Shows for a 6 transceiver cell, maximum power output in busy hour is likely to be ~30-40% of the theoretical capability of the cell
Exposure guidelines and measurement standards

Specific Absorption Rate (SAR) is the measure of the rate of energy deposited in the human body from an RF field.

International guidelines recommend max SAR for general public

- ICNIRP – peak 2 W/kg in 10g head / trunk & 0.08 W/kg over whole body
- IEEE – peak 1.6 W/kg in 1g head / trunk & 0.08 W/kg over whole body
- Guidelines also specify frequency-dependent reference field levels

Current Standards define how to measure SAR for handsets used against the ear: Global (IEC), EU (CENELEC), US (IEEE)

IEC developing SAR measurement standard for equipment used close to the body

- Current US FCC measurement guidelines

In EU, CENELEC are finalising standards on base station RF field measurement. IEC / ITU are developing global base station standards
Field levels are subject to a power law decay.

The RF Field decays rapidly as you move away from base station. Ignoring antenna directivity, reflection & scatter effects, a point 10 times further away from a transmit antenna will have less than 1/100 power flux.
Exposure from base stations - observed

- RA* evaluated levels at 289 schools with/near base stations
- Measurements made in many locations at each school
- Highest result for each school were referenced to ICNIRP_GP.
- Graph shows % of schools below the ICNIRP_GP compliance factor.
  - Factor “1” = ICNIRP_GP

Very low public RF exposure

UK RA cellular RF survey 2001 -> 2004
Highest levels measured from 289 Schools

*UK Radiocommunications Agency, now part of OFCOM
Exposure from base stations – numbers game

- 50 x ICNIRP_GP: exposure to 4 W/kg could produce a rise in body temperature of 1°C

- 5 x ICNIRP_GP: ICNIRP recommends limiting exposure of workers to 0.4 W/kg

- ICNIRP: recommends limiting public exposure to 0.08 W/kg

- Maximum field in any of the schools surveyed was 1/279 x ICNIRP_GP

- Median field for the schools surveyed was 1/17970 x ICNIRP_GP

"Exposure levels from living near to mobile phone base stations are extremely low, and the overall evidence indicates that they are unlikely to pose a risk to health.”

AGNIR – January 2004
Effect of power control on the handset

- Handset power set by network instructions
  - power control range for GSM is ~1000X (30dB) @ 3dB per 60ms

- In-service communications loss from base station to handset varies by ~10,000,000 (70dB)

- >> loss in larger area further away from base station

- Explains observation that most likely GSM handset powers are at max or min setting

- 3G power control range
  - >70dB @ 2dB per 0.7ms
  - better match to communications loss

Population of each GSM power control setting*

*Output power levels from mobile phones in different geographical areas; implications for exposure assessment; S Lonn, U Forssen, P Vecchia, A Ahlbom, M Feychtling. Occup Environ Med 2004;61:769–772. doi: 10.1136/oem.2003.012567
SAR from Mobile Phones

- Measured head-use SAR from compliance test varies 3X fold between products
  - Vodafone UK’s handsets 1.05 and 0.31 W/kg

- Comparing head-compliance SAR values between products is not a reliable guide to how SAR may vary between products for other positions of use or in different operating bands
  - Vodafone retail store manager...
    “I have a man in the store who wants a high SAR phone because he lives in a rural area and said it was more powerful and would work better!”

- UK MTHR research concludes that using a Personal Hands Free with the lead wrapped around the phone gives a 60% reduction in peak head SAR compared with phone used against the ear – a 2 or 3 fold factor SAR reduction.

- Published data shows that a correctly-used PHF reduces peak head SAR by 95% or more compared with phone used against the ear – a 20 fold factor SAR reduction.
Moving away from the head

- Vodafone supports research to assess effects on SAR of
  - different body mounting positions
  - different operating frequency bands

- Feeds international measurement standards

- Empower users by giving effective advice on how they may limit the SAR from their phone if they are concerned
Summary

- The way people use mobile phones has changed significantly over the last 30 years
- Commercial drivers to use spectrum efficiently and to maximise battery life work to reduce transmit power
- Demands for coverage & capacity increase number of base stations
- GSM is spectrum efficient – but 3G is better, enabling higher data rate services for similar power
- Design of network impacts handset power - hence SAR
- User actions are more effective in controlling exposure from their handset than comparisons between different products’ compliance-based SAR numbers