Green Wireless Systems

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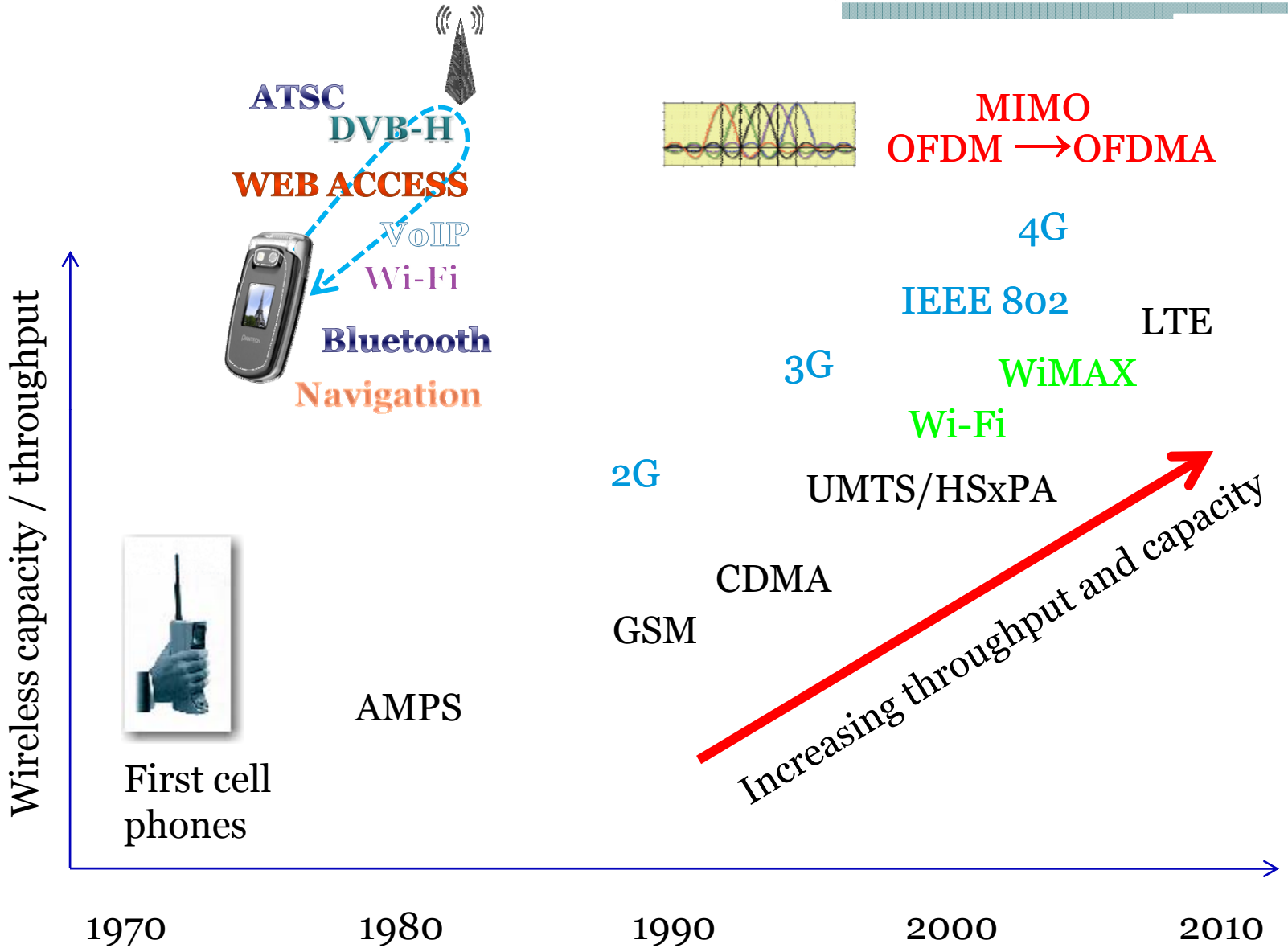
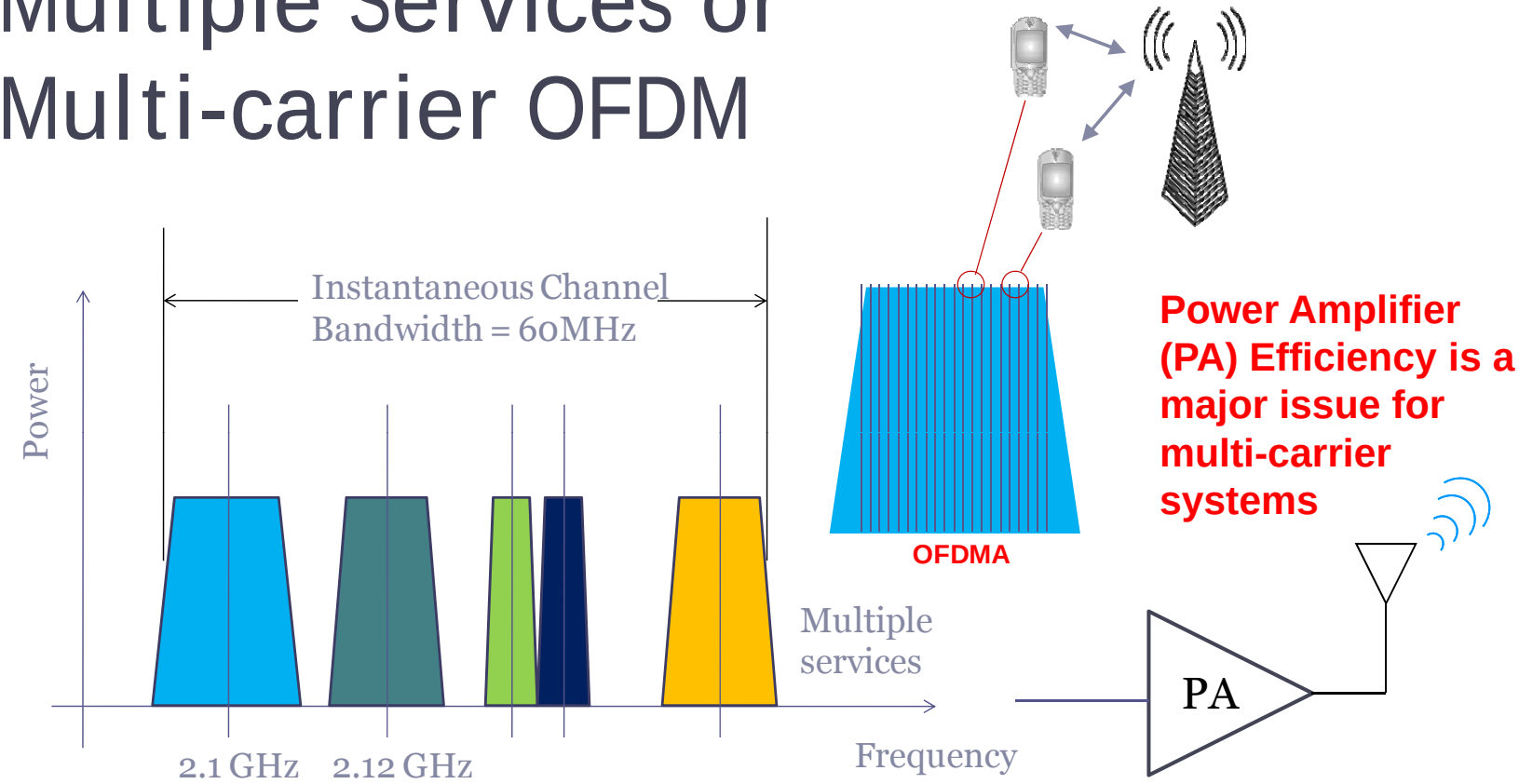
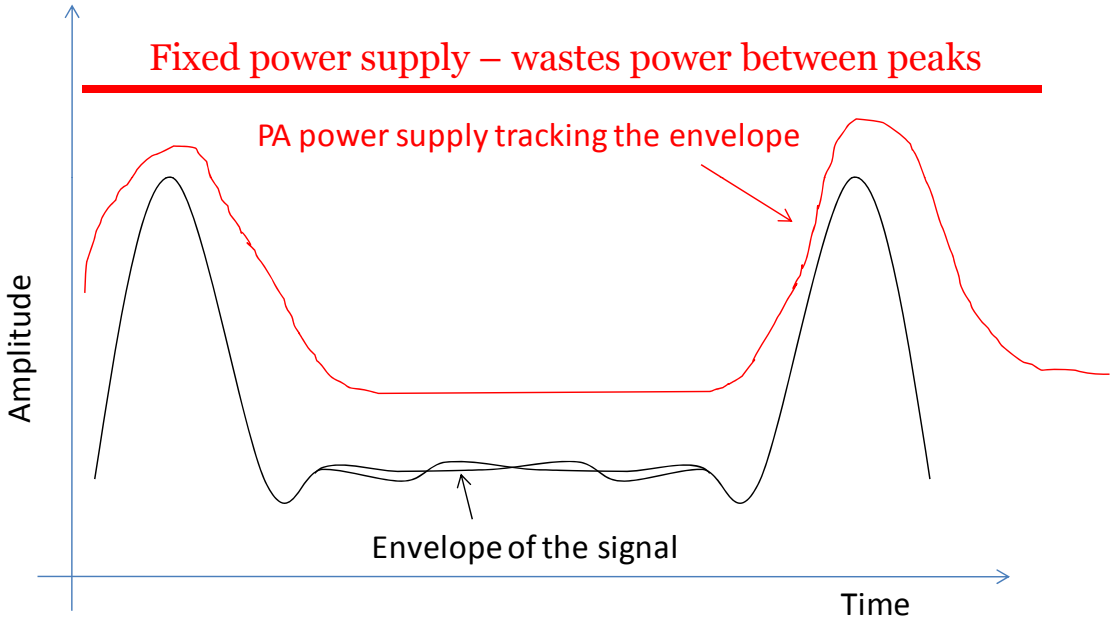

ATSC
DVB-H
WEB ACCESS
VoIP
Wi-Fi
Bluetooth
Navigation
MIMO
OFDM →OFDMA
4G
IEEE 802
LTE
3G
WiMAX
Wi-Fi
2G
UMTS/HSxPA
CDMA
GSM
AMPS
First cell phones
Wireless capacity / throughput
Increasing throughput and capacity
1970
1980
1990
2000
2010

Multiple Services or Multi-carrier OFDM



- Multiple RF carriers transmitted through a single PA create power peaks, which result in PA inefficiencies
- Inefficiencies are due to providing enough power to the PA to handle occasional peaks
  - Typical PA today is about 15% efficient

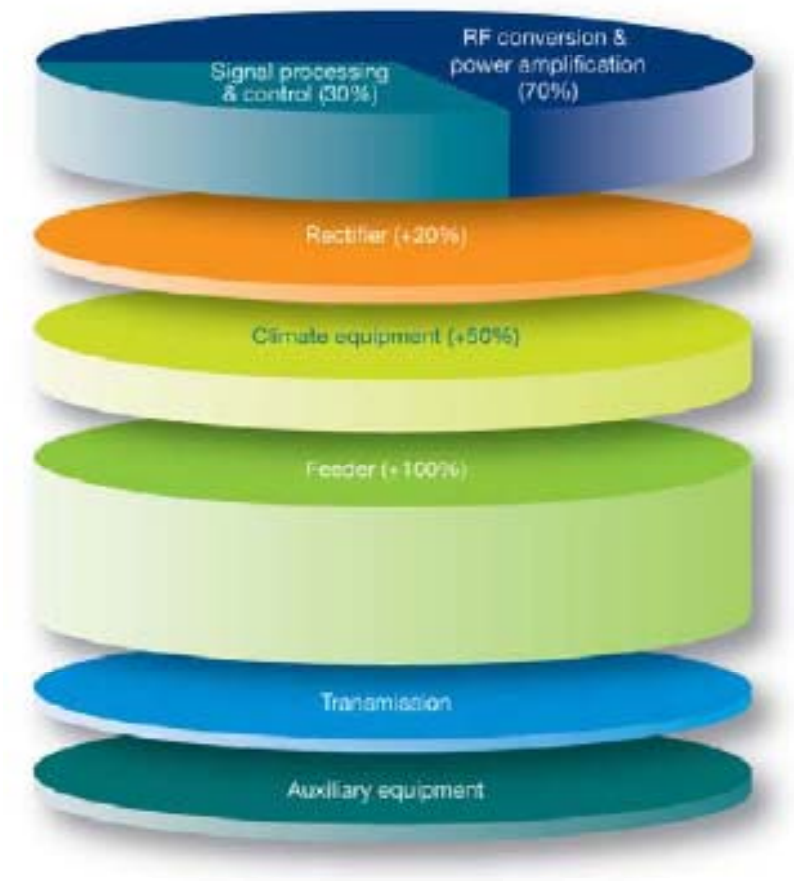
Power Amplifier (PA) Efficiency



- Typical PA efficiencies are about 10-15%
- Envelope tracking PAs are being developed to improve PA efficiency

Energy Use of Typical Macro BS

- Typical macro base station site includes
  - Battery back-up units
  - Air conditioning equipment
  - Diesel generators to charge the batteries during longer power disruptions or where direct connection to the electrical grid is impossible



Energy consumption at a typical macro base station site

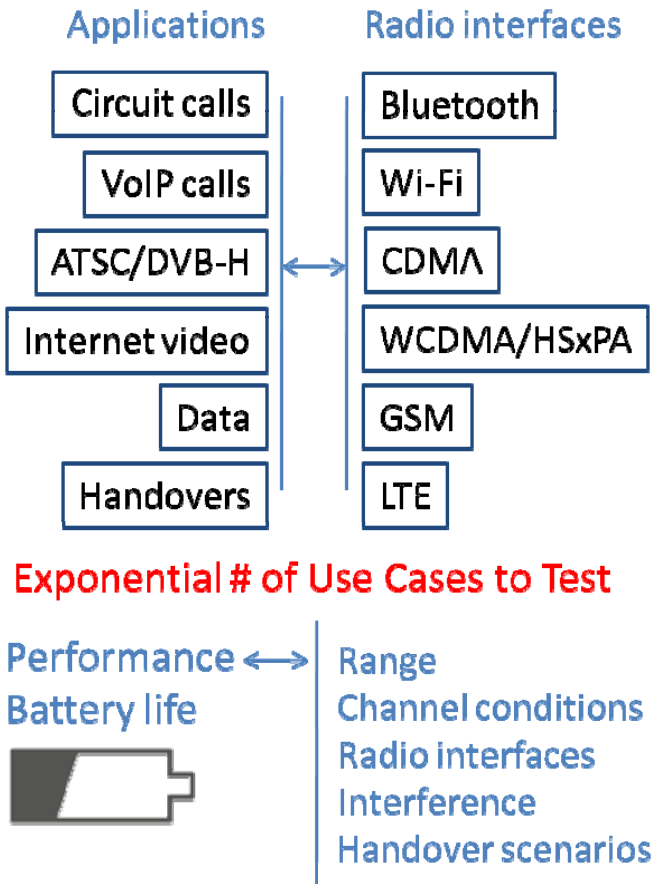
Source: Ericsson

New Generation Small Base Stations

- High efficiency PAs result in smaller, lighter radio heads as the size/weight of heat-sinks (metal blocks) is reduced
- The radio heads can be placed on the towers next to the antennas, eliminating the heavy and “lossy” coaxial cable that has traditionally been used to get the signal up to the antenna on a tower

Handset Power Issues

- Handsets are evolving to run mobile applications, such as video, Internet access, VoIP, location and other services...
- ... enabled by new generation radios, such as 3G/WCDMA and emerging 4G/LTE
- Performance and roaming behavior are currently measured primarily for circuit voice services
- Battery life is specified for *talk minutes* and *standby minutes*
- Performance of emerging mobile applications is little understood
- Battery life of 3G and 4G radios need to be carefully qualified as a function of use cases and handover scenarios
- The number of use cases and test cases is growing exponentially

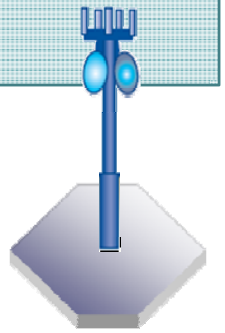


Power Issues

Handset

- Battery life
- Battery life
- Battery life
- Smartphone gadgets draw power
  - Video – Internet streaming, ATSC (LG Lotus), DVB-H
  - Internet access
  - Email
- Battery specs of ‘talk time’ and ‘standby time’ are no longer sufficient
- GSMA DG09 document “Battery Life Measurement Technique”
  - Battery life specified based on usage profiles

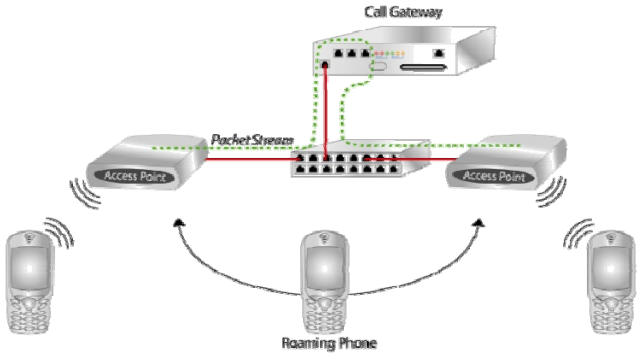
Base Station

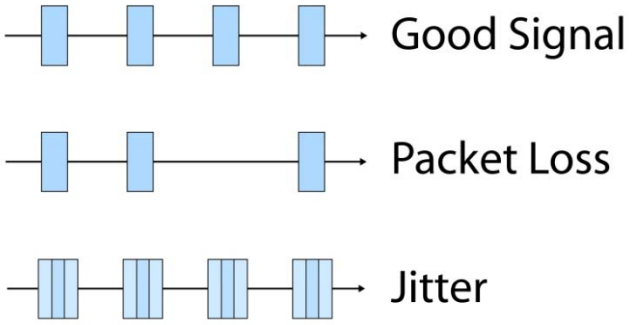


- Heat sinking
  - Weight
  - Size
- Air conditioning
- Back-up generator capacity
- Alternative power feasibility
  - Solar
  - Wind
- Most power in the radio network is dissipated by PAs
- PA efficiency must improve to enable smaller, cheaper base stations

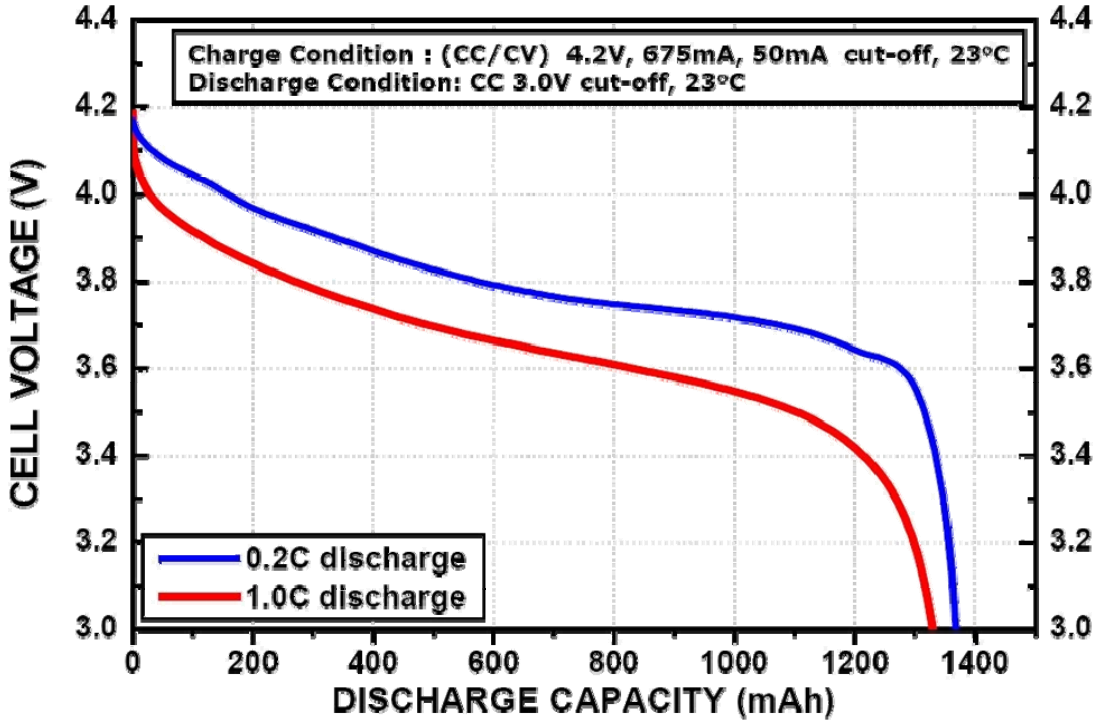
Power Management – Sleep Modes

- WiMAX, LTE, 802.11 and other standards define mechanisms to let devices go to sleep between transmissions
- Devices can schedule sleep periods with base stations to
  - Consolidate receive/transmit intervals and extend battery life of handsets
  - Improve airlink efficiency through careful traffic scheduling
- Scheduling and sleep protocols are complex and will take time to get implemented in handsets





Battery Technology



- Li-ion is a 10-year-old technology
- Typical voltage range of a Li-ion cell is 3.0-4.2V
- New Li-ion chemistries extend the range to 2.5-4.35V adding about 15% to battery capacity...but
- PAs become less efficient over wider range, thereby canceling the gains in battery life

Energy Efficiency – Center Stage

Numerous papers on energy efficiency published by Ericsson and other manufacturers

"Operators are becoming increasingly aware of their energy bills. Consequently, Ericsson is committed to developing solutions that reduce operating costs and effects on the environment."

Ericsson, "Energy efficiency enhancements in radio access networks"