LTE – new challenges

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Agenda

1. Why LTE?
2. 3GPP Standardization
3. UMTS to LTE improvements
4. Measurement equipment
5. KPI's
6. LTE - examples of results

Why LTE?

Motivation for LTE

- **Need for higher data rates and greater spectral efficiency**
  - *Can be partialy achieved with HSDPA/HSUPA but fully with new air interface defined by 3GPP LTE*
- **Need for Packet Switched optimized system**
  - *Evolve UMTS towards packet only system*
- **Need for high quality of services**
  - *Use of licensed frequencies to guarantee quality of services*
  - *Always-on experience (reduce control plane latency significantly)*
  - *Reduce round trip delay*
- **Need for cheaper infrastructure**
  - *Simplify architecture reduce number of network elements*

Why LTE?

LTE performance requirements

- **Data Rate:**
  - *– Instantaneous downlink peak data p rate of 100Mbit/s in a 20MHz downlink spectrum (i.e. 5 bit/s/Hz)*
  - *– Instantaneous uplink peak data rate of 50Mbit/s in a 20MHz uplink spectrum (i.e. 2.5 bit/s/Hz)*
- **Cell range**
  - *– 5 km - optimal size*
  - *– 30km sizes with reasonable performance*
  - *– up to 100 km cell sizes supported with acceptable performance*
- **Cell capacity**
  - *– up to 200 active users per cell(5 MHz) (i.e., 200 active data clients)*

Why LTE?

LTE performance requirements

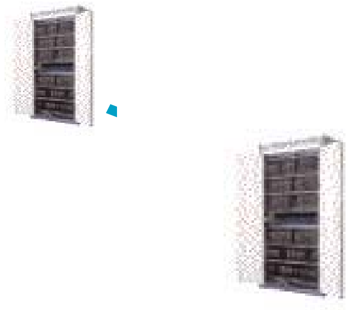
- **Mobility**
  - *optimized for low mobility(p y(0-15km/h) but supports high speed*
- **Latency**
  - *user plane < 5ms*
  - *control plane < 50 ms*
- **Improved spectrum efficiency**
- **Improved broadcasting**
- **IP-optimized**
- **Scalable bandwidth of 20, 15, 10, 5, 3 and 1.4MHz**
- **Co-existence with legacy standards**

3GPP Standardization

GSM → UMTS → LTE

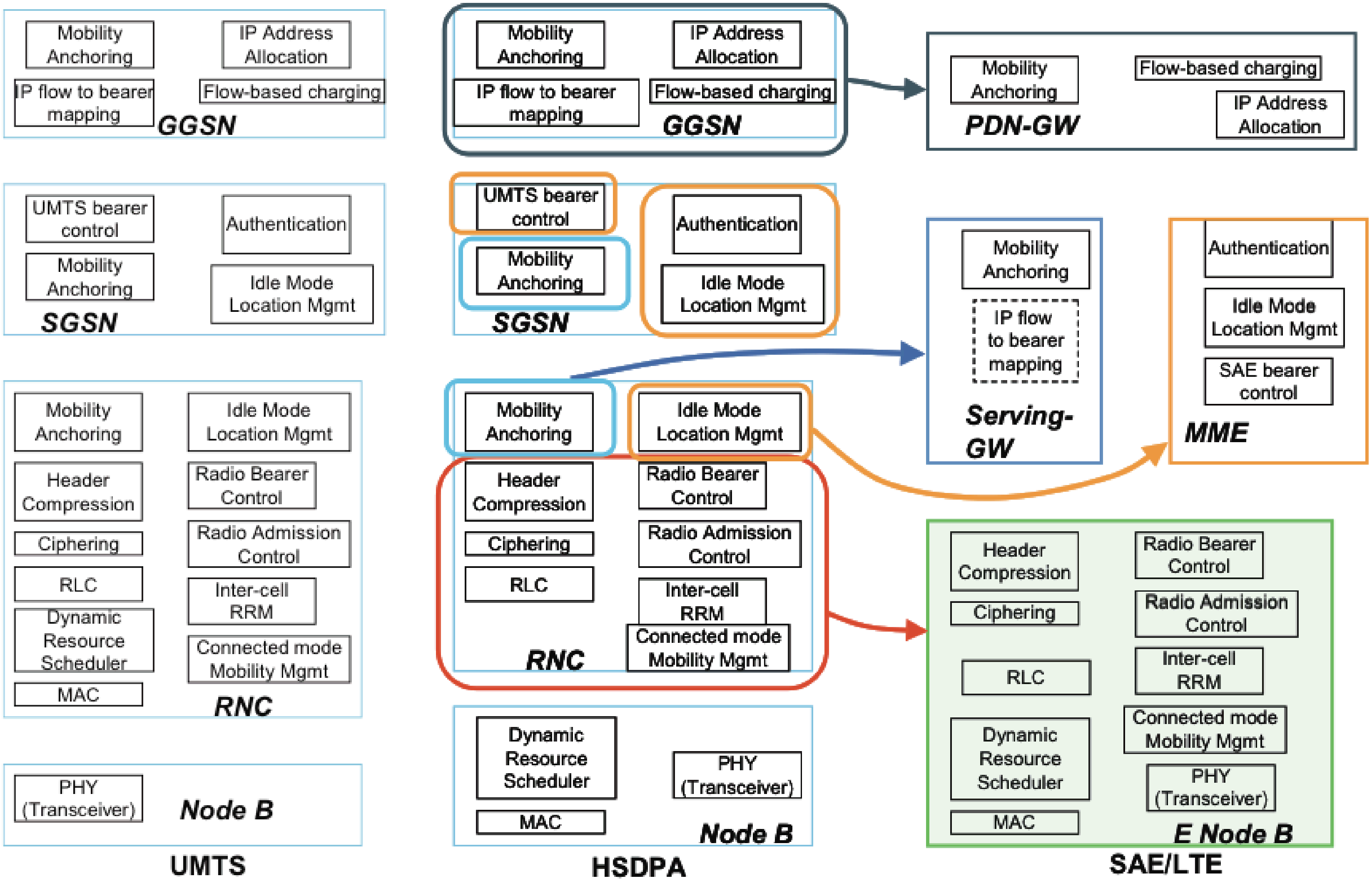
Version	Released	Info
Release 98	1998	Specified pre-3G GSM network
Release 99	2000 Q1	Specified the first version of UMTS, in- corporating a CDMA air interface
Release 4	2001 Q2	aka. Release 2000, added all-IP Core Network
Release 5	2002 Q1	Introduced IMS and HSDPA
Release 6	2004 Q4	Integrated operation with Wireless LAN networks and added HSUPA, MBMS, enhancements to IMS
Release 7	2007 Q4	Decreasing latency, improvements to QoS and real-time applications, HSPA+ , NFC, EDGE Evolution.
Release 8	2008 Q4	First LTE release. All-IP Network (SAE), new OFDMA, FDE and MIMO based radio interface.
Release 9	2009 Q4	SAES Enhancements, Wimax and LTE/UMTS Interoperability
Release 10	**2011 Q1**	**LTE advanced**

LTE architecture simplification



- ✓ LTE lack of RNC
- ✓ LTE big changes in CN

LTE functional simplification



UMTS and LTE services approach

Through a combination of very high downlink (and uplink) transmission speeds, more flexible, efficient use of spectrum and reduced packet latency, LTE promises to enhance the delivery of mobile broadband services while adding exciting new value-added service possibilities.

Service category	Current environment	LTE environment
Rich voice	Real-time audio	VoIP, high quality video conferencing
P2F messaging	SMS, MMS, low priority e-mails	Photo messages, IM, mobile e-mail, video messaging
Browsing	Access to online information services, for which users pay standard network rates. Currently limited to WAP browsing over GPRS and 3G networks	Super-fast browsing, uploading content to social networking sites
Paid information	Contentforwhich users pay over and above standard network charges. Mainly text- based information.	E-newspapers, high quality audio streaming
Personalisation	Predominantly ringtones, also includes screensavers and ringbacks	Realtones (original artist recordings), personalised mobile web sites
TV/ video on demand	Streamed and downloadable video content	Broadcast television services, true on-demand television, high quality video streaming
Music	Full track downloads and analogue radio services	High quality music downloading and storage
Content messaging and cross media	Peer-to-peer messaging using third party content as well as interaction with other media	Wide scale distribution of video clips, karaoke services, video-based mobile advertising
M-commerce	Commission on transactions (including gambling) and payment facilities undertaken over mobile networks	Mobile handsets as payment devices, with payment details carried over high speed networks to enable rapid completion of transactions
Mobile data networking	Access to corporate intranets and databases, as well as the use of applications such as CRM	P2P file transfer, business applications, application sharing, M2M communication, mobile intranet/ extranet

UMTS and LTE comparison

The key of LTE and specific comparison with today's UMTS/HSPA networks:

- ✓ **Enhanced air interface allows increased data rates:** LTE is built on an all-new radio access network based on OFDM (Orthogonal Frequency-Division Multiplexing) technology. Specified in 3GPP Release 8, the air interface for LTE combines OFDMA-based modulation and multiple access scheme for the downlink, together with SC-FDMA (Single Carrier FDMA) for the uplink. The result of these radio interface features is significantly improved radio performance, yielding up to five times the average throughput of HSPA. Downlink peak data rates are extended up to a theoretical maximum of 300 Mbit/s per 20 MHz of spectrum. Similarly, LTE theoretical uplink rates can reach 75 Mbit/s per 20 MHz of spectrum, with theoretical support for at least 200 active users per cell in 5 MHz.
- ✓ **High spectral efficiency:** LTE's greater spectral efficiency allows operators to support increased numbers of customers within their existing and future spectrum allocations, with a reduced cost of delivery per bit.
- ✓ **Flexible radio planning:** LTE can deliver optimum performance in a cell size of up to 5 km. It is still capable of delivering effective performance in cell sizes of up to 30 km radius, with more limited performance available in cell sizes up to 100 km radius
- ✓ **Reduced latency:** By reducing round-trip times to 10ms or even less (compared with 40–50ms for HSPA), LTE delivers a more responsive user experience. This permits interactive, real-time services such as high-quality audio/videoconferencing and multi-player gaming.

UMTS and LTE comparison

The key of LTE and specific comparison with today's UMTS/HSPA networks:

- ✓ **An all-IP environment:** One of the most significant features of LTE is its transition to a 'flat', all-IP based core network with a simplified architecture and open interfaces. Indeed, much of 3GPP's standardisation work targets the conversion of existing core network architecture to an all-IP system. Within 3GPP, this initiative has been referred to as Systems Architecture Evolution (SAE) – now called Evolved Packet Core (EPC). SAE/EPC enables more flexible service provisioning plus simplified interworking with fixed and non-3GPP mobile networks.
- ✓ **Co-existence with legacy standards and systems:** LTE users should be able to make voice calls from their terminal and have access to basic data services even when they are in areas without LTE coverage. LTE therefore allows smooth, seamless service handover in areas of HSPA, WCDMA or GSM/GPRS/EDGE coverage. Furthermore, LTE/SAE supports not only intra-system and inter-system handovers, but inter-domain handovers between packet switched and circuit switched sessions.
- ✓ **Extra cost reduction capabilities:** The introduction of features such as a multi- vendor RAN (MVR) or self optimising networks (SON) should help to reduce opex and provide the potential to realise lower costs per bit.

Measurement equipment we use

Test & Measurement	Benchmarking	
Diversity Optimizer	**Diversity Ranger**	**Diversity Benchmarker**

Test & Measurement

Diversity Optimizer

- **Troubleshooting and optimisation**
- Laptop-based solution
- In-car, indoor and walk testing
- Portable, lightweight, economic with full test capability
- Up to 4 devices simultaneous and RF scanner

Benchmarking

Diversity Ranger

- **Flexibility**:
  - Network Benchmarking and Multi Channel Network Optimization
  - Fully featured tool for indoor, in-car, in-train and walk testing
  - Option to add an RF Scanner
- **Portability:**
  - Unmatched low weight system and ruggedized tablet device
  - All-weather, all-terrain
  - Long autonomy granted by hot-swappable batteries
  - WLAN communication to visualization device

Diversity Benchmarker

- **Modularity:** Cascadeable PC modules
  - Up to 8 modules for a true benchmarking approach
  - Up to 16 test devices per system
- **Flexibility**: Extensive technologies and devices support for more than100 test devices
- **Reliability:**
  - Very low hardware failure rate
  - Diversity has a return rate of approximately 1%

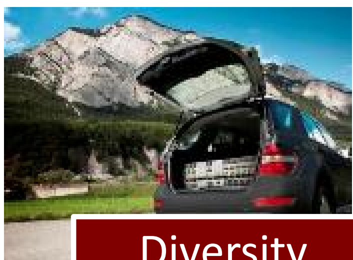
Measurements test cases

	2-2.5G	3G	4G
• Air Interface logging	✓	✓	✓
• Forcing Functions ***(Technology/Band)***	✓	✓	✓
• Voice Call testing ***(Call To Any)***	✓	✓	✓**
• Speech Testing ***(SQUAD, PESQ or POLQA NB and WB)*** ***M->L and M->M, MOC and MTC, DL and UL, VoIP (Skype-Counterpath)***	✓	✓	✓**
• Speech Advanced: ***echo concelling, noise suppression, RTT***	✓	✓	✓**
• Data ***Ping, Trace Route, FTP DL/UL, HTTP DL/UL,*** ***Capacity UL/DL (multi thread HTTP), IPERF UDP***	✓	✓	✓
• HTTP & WAP Browsing	✓	✓	✓**
• Messaging ***(SMS, MMS, Email)***	✓	✓	✓**
• Multi-Mix job **(Sequence of Voice and Data)**	✓	✓	✓**
• Multi-RAB job ***(Simultaneous Voice and Data)***	✓	✓	✓**
• Video Streaming ***(intrusive & non-intrusive) YouTube-Portals-IP TV***	✓	✓	✓

**CSFB or VoLTE

Measurement Equipment- NQDI

Measurement Files



Diversity

QualiPoc

NQDI Server

Storage

MS SQL

NQDI Client

Search

Analyse

Report

Plot

Compare

Postprocesing Tool

Measurement Equipment- NQDI

Scalable and Centralized

- MS SQL Server based
- From standalone laptop to Enterprise Client/Server configurations

Technologies

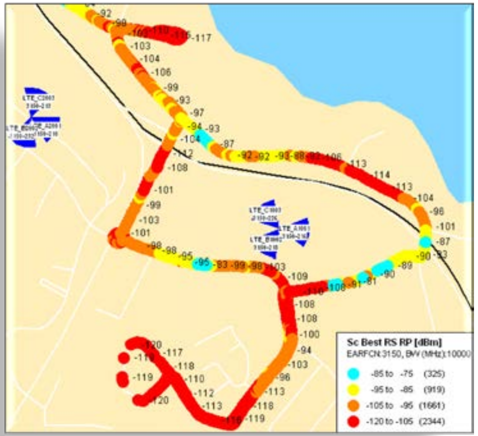
- GSM, GPRS, EDGE, WCDMA R99, HSDPA, HSUPA, HSPA+, HSPA-DC, LTE FDD, TD-LTE, CDMA2000, EV-DO, IS-136, iDEN, WiMAX, and WiFi

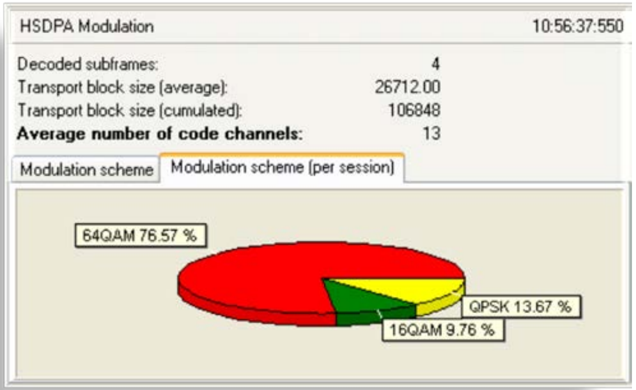
GUI

- Smart context adapting GUI
- Tabbed or detached floating windows
- Customisable displays
- Powerful data search and filtering
- Time synchronized views

Reporting

- Facilitates Benchmarking reporting
- Unique MS Excel KPI report generator
- Map plots in MapInfo and Google Earth





KPI’s LTE and Service

Stratum	Type	Function	KPI	Standard
Service	Voice	Voice(LTE CSFB) - Telephony	SuccessRate/Duration	ETSI
Service	Voice	Voice(LTE CSFB) - Telephony Fallback Delay	SuccessRate/Duration	ETSI
Service	Voice	Voice(LTE CSFB) - Telephony Service	SuccessRate/Duration	ETSI
Service	Voice	Voice(LTE CSFB) - Radio Fallback Delay	SuccessRate/Duration	ETSI
Layer3	LTE	Signal Channel	SuccessRate/Duration	ETSI
Layer3	LTE	Security Mode	SuccessRate/Duration	ETSI
Layer3	Data	Attach EPS	SuccessRate/Duration	ETSI
Layer3	Data	Detach EPS	SuccessRate/Duration	ETSI
Layer3	Data (EPS)	Default EPS Bearer	SuccessRate/Duration	ETSI
Layer3	Data (EPS)	Signal Channel	SuccessRate/Duration	ETSI
Layer3	Data (EPS)	Attach EPS	SuccessRate/Duration	ETSI
Service	Voice	Telephony	Speech Quality	ETSI
Layer3	LTE	Tracking Area Update	SuccessRate/Duration	ETSI
Layer3	LTE	IntersystemHO (4G/3G)	SuccessRate/Duration	ETSI
Layer3	LTE	IntersystemCha nge (3G/4G)	SuccessRate/Duration	ETSI

KPI's LTE and Service

Stratum	Type	Function	KPI	Standard
Service	Data	Email Send/Recive	SuccessRate/Duration/Performance	ETSI
Service	Data	FTP download/upload	SuccessRate/Duration/Performance	ETSI
Service	Data	HTTP Transfer	SuccessRate/Duration/Performance	ETSI
Service	Data	HTTP Browser	SuccessRate/Duration/Performance	ETSI
Service	Data	Capacity Get/Put	SuccessRate/Duration/Performance	ETSI
Service	Data	Video Streaming	SuccessRate/Duration/Performance	ETSI
Service	Data	Youtube	SuccessRate/Duration/Performance	ETSI
Service	Voice	Voice (LTE CSFB) - Telephony Radio Redirect	SuccessRate/Duration	-
Service	Voice	Voice (LTE CSFB) - Technology Change Delay	SuccessRate/Duration	-
Service	Voice	Voice(LTE CSFB) - Telephony Return Delay	SuccessRate/Duration	-
Layer3	LTE	Modify EPS Bearer	SuccessRate/Duration	-
Layer3	LTE	Handover	SuccessRate/Duration	-

KPI's for LTE new approaches

- ✓ **High Speed Mobile Data Networks**
- ✓ **Algorithms for Voice and Video**
- ✓ **Video Streaming**
- ✓ **VoLTE**

ETSI Standards

Speech and multimedia Transmission Quality (STQ)
QoS aspects for popular services in mobile network

- ETSI TS 102 250-1 Part 1: Assessment of Quality of Service
- ETSI TS 102 250-2 Part 2: Definition of Quality of Service parameters and their computation
- ETSI TS 102 250-3 Part 3: Typical procedures for Quality of Service measurement equipment
- ETSI TS 102 250-4 Part 4: Requirements for Quality of Service measurement equipment
- ETSI TS 102 250-5 Part 5: Definition of typical measurement profiles
- ETSI TS 102 250-6 Part 6: Post processing and statistical methods
- ETSI TS 102 250-7 Part 7: Network based Quality of Service measurements

KPI for Evolved Universal Terrestrial Radio Access Network (E-UTRAN)

- ETSI TS 132 450 Definitions
- ETSI TS 132 451 Requirements
- ETSI TS 132 454 KPI for the IMS
- ETSI TS 132 455 KPI for the Evolved Packet Core

High Speed Mobile Data Networks - new ways…

Motivation

Traditional tests such as FTP, Email, HTTP Transfer, Ping, HTTP Browser, YouTube, RealPlayer, Skype,... emulate end user behaviour and are used to measure end user perceived quality.

The issues are

1. One can’t just continue to add more test cases for every new app (gaming, whatsapp,...). Otherwise, the test effort would just explode. Furthermore, one would not gain new information!
2. Such Apps & Services do often not stress the limits of high speed data networks

Key is to figure out, which test cases need to be combined to cover all the needs!

High Speed Mobile Data Networks - new ways…

Application vs. Network testing

- **Data applications testing**
  - Generic user oriented services, as e.g.
    - FTP Up- and Down-Load
    - HTTP Up- and Down-Load
    - HTTP browsing
    - Video Streaming
    - E-Mailing
  - Results also depend on client (or server) implementation
  - Emulates the use of a dedicated service by a user
  - Application throughput is one metric

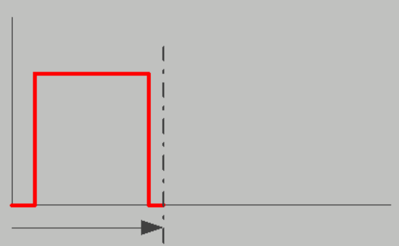
- **Network capacity testing**
  - Not a user application test!!
  - Throughput capacity of the network / cell
  - Multi-threaded or multisocket throughput testing
    - Not limited in transfer-rate by RTT
    - Not limited by non-optimal TCP window size of the client
    - Not limited by data server (UL) bandwidth
  - Evaluates network transport capacity

High Speed Mobile Data Networks - new ways…

How to classify a data network

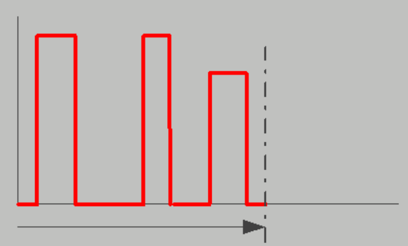
Single file up- and download

- What the user does
  - Cloud synchronization
  - File- / App-download
  - E-mail attachments
  - (FTP transfer)
- What is the technical behind?
  - Single connection over TCP (HTTP)
- How is the ‚flow of use‘?
  - Up- or Download
  - Task over
  - ➔ The faster the better



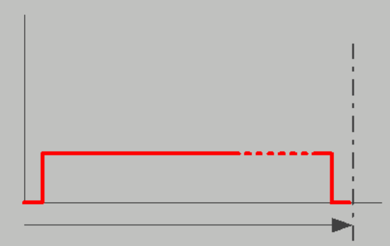
HTTP interaction

- What the user does
  - HTML web browsing
  - News feeds
- What is the technical behind?
  - Single or multiple connections over TCP (HTTP)
- How is the ‚flow of use‘?
  - Initial Up- or Download
  - ‚off-line‘ pœ essing
  - Update
  - ➔ Pulse-like load
  - ➔ Ramp-up becomes important



Continuous up-/downstream

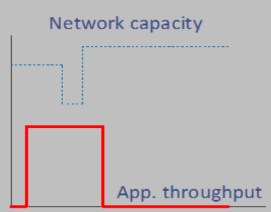
- What the user does
  - YouTube video stream
  - Internet-TV / Internetradio
  - Webcam upstream
  - Gaming (?)
- What is the technical behind?
  - Single medium load connection
  - Using HTTP or RTSP
- How is the ‚flow of use‘?
  - Triggering task
  - Long term use
  - ➔ Continous, minimal interruptions



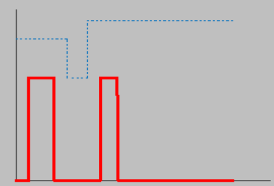
High Speed Mobile Data Networks - new ways…

- The application tests presents what a user would get
- It is not (always) an indicator for available capacity, especially in high-speed networks

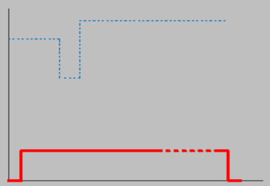
Application test: **HTTP transfer**
- Up- / download of files over HTTP
- Single connection



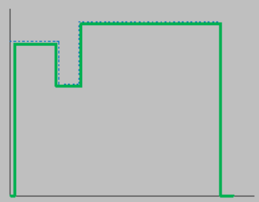
Application test: **HTTP Browsing**
- Download HTML sites (HTTP)
- Parallel download

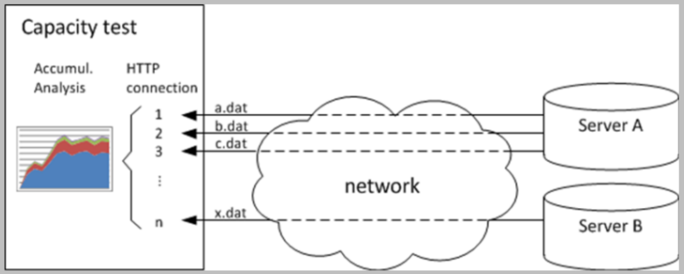


Application test: **Video Streaming**
- Long term down-stream
- Single connection
- Throughput limited by video bitrate



Capacity test – not an application test
- Up- / download of multiple files over HTTP
- Multiple connections
- Take as much as you can





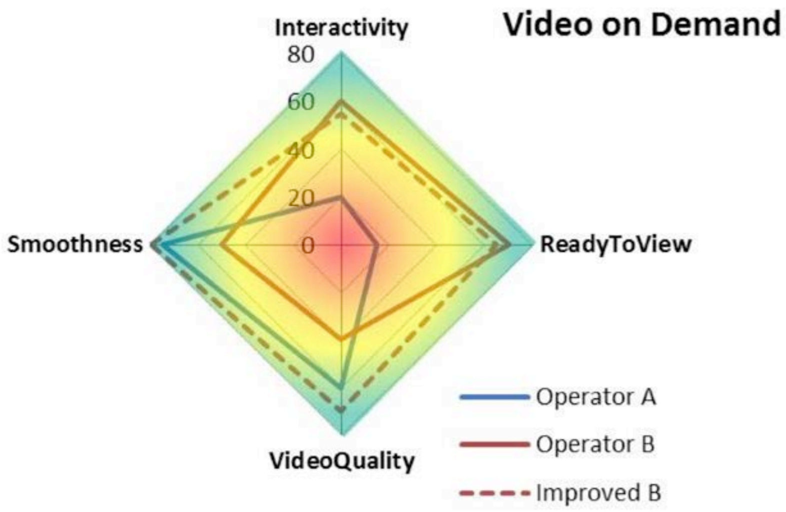
Systemics PAB

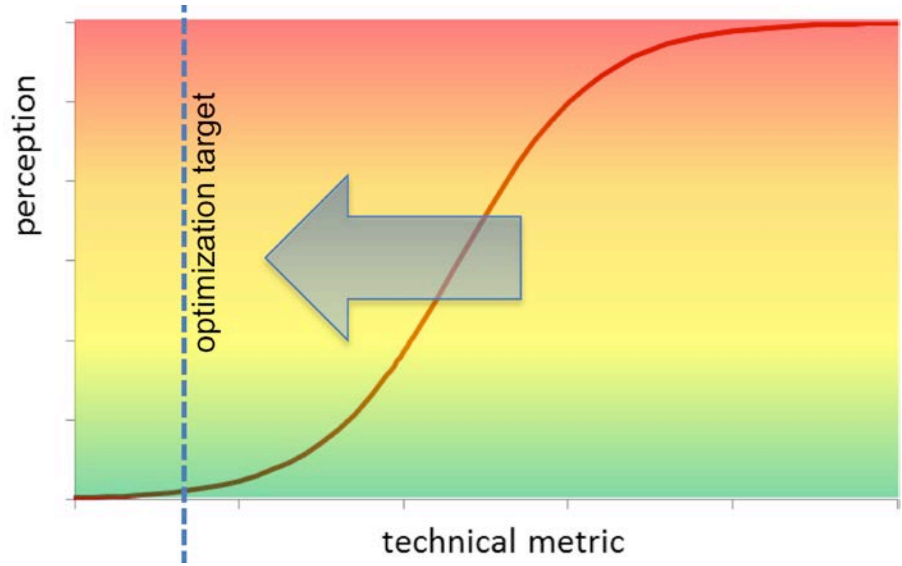
High Speed Mobile Data Networks - new ways…

Next Steps

Probably, one can't afford to continue and test each and every new data app or service

A better way is to profile such services and derive the user percieved quality from services which behave similar. Then set the Quality thresholds to define what is 'good' and what is 'bad'





Algorithms for Voice and Video

Intrusive speech:

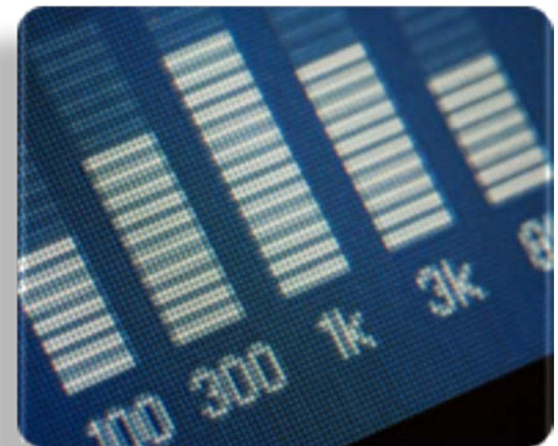
- P.OLQA **(ITU-T P.863)**
- SQuad-LQ Clean speech testing
- SQuad-NS Noisy speech testing
- SQuad-AEC Acoustic Echo testing
- PESQ (ITU-T P.862)

Non-intrusive speech:

- P.563
- NiNA+ **(ITU-T P.563)**

Video (intrusive and non-intrusive):

- VQuad-HD **(ITU J.341)**
- VMon



Video Streaming... technology is changing: adaptive bitrate streaming

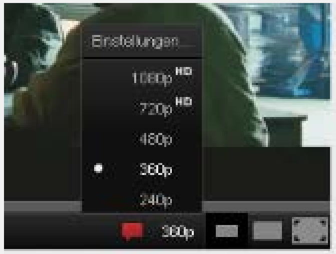
Technological evolution for streaming multimedia after simple progressive download of constant bitrate videos

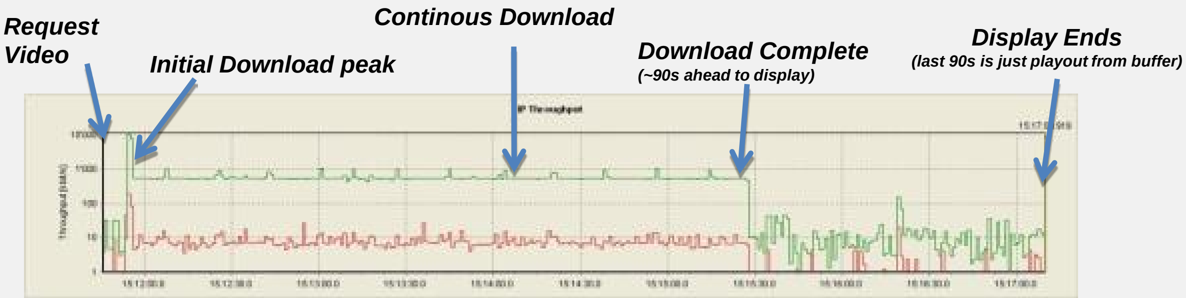
- The protocol used is still HTTP. Video is segmented into small multi-second parts (from 2 to 10) and encoded in multiple bit rates.
- Resolution is dynamically adapted to user's bandwidth, CPU capacity, battery level, screen size.
- Recently adopted also by YouTube, market share of Adaptive Bitrate Streaming in 2012 is 17% but expected to jump to 50% in 2015.

As a result Video quality is not fixed anymore!
Visual quality measurement is paramount.

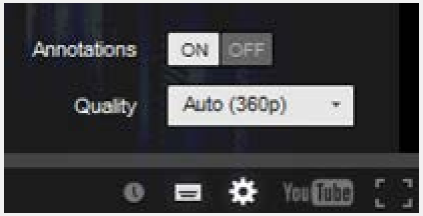
Video Streaming... technology is changing: adaptive bitrate streaming

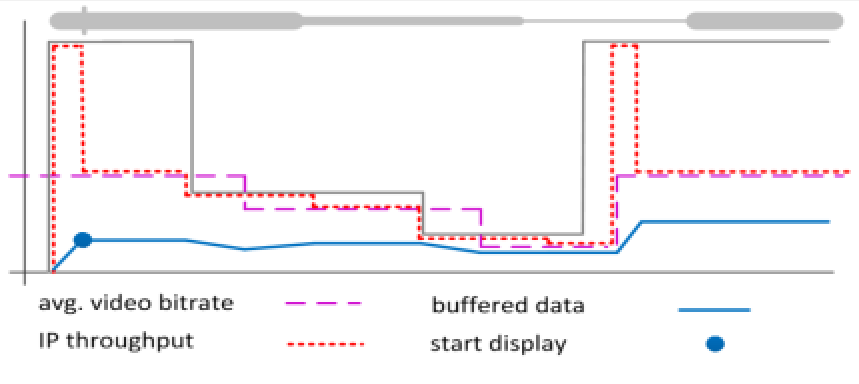
Progressive download





Adaptive Bitrate Streaming





Video Streaming... technology is changing: adaptive bitrate streaming

More complex technology but many advantages

Better customer experience

Always go for the best sustainable quality. Automatically.
Dynamic bitrate means less buffer under-runs (hence less freezing).
20% reduction in buffering measured in You Tube.

Scalability

Uses current Internet infrastructure (no specialized streaming servers).

Firewall friendly

Goes through normal firewall ports used by web browsers.

Load reduction

Video chunks can be cached by proxies and distributed to CDNs and HTTP servers.

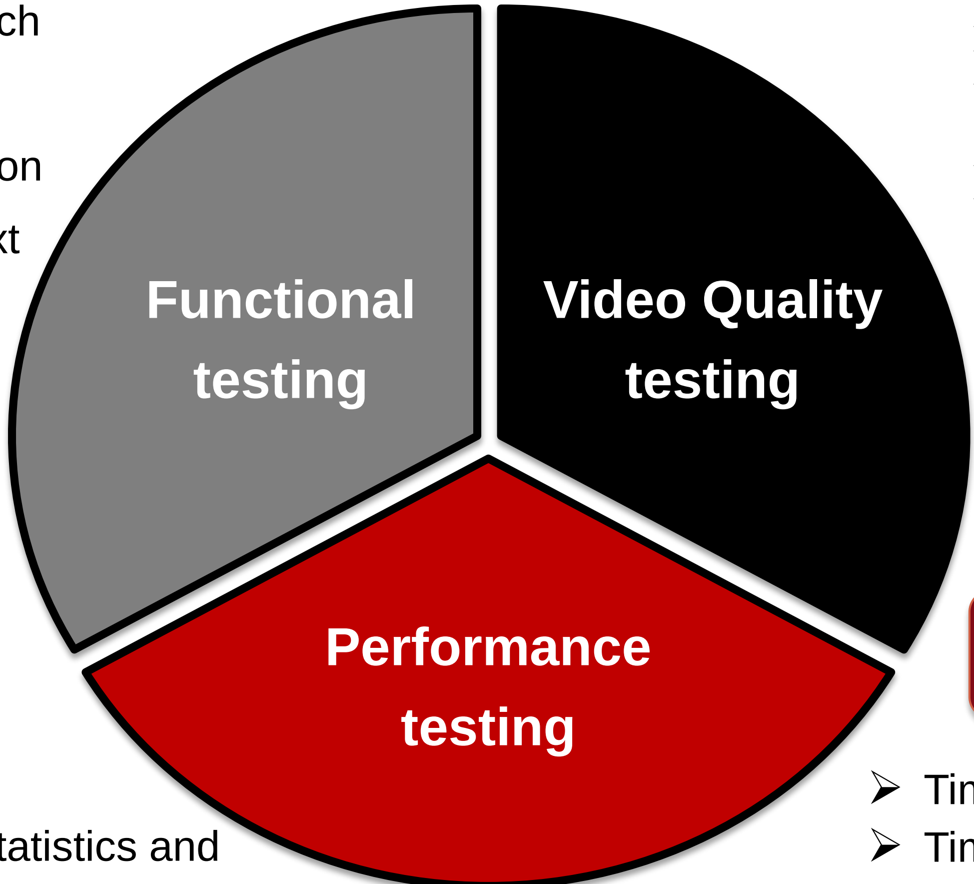
Easier job for content and search providers

No more guesswork on what bitrates to encode for end devices.
Video chunks created for a live stream can be kept for later VoD delivery.
Searches can go down to chunk level, not full video. Ads can be inserted.

Video Streaming... technology is changing: adaptive bitrate streaming

Video testing

- Network attach
- DNS request
- DNS resolution
- HTML context download
- …



- Video MOS
- Freezing / Re-Buffering
- Spatial and temporal dimensions
  - PSNR, SSIM, Blurriness, Blockiness, Slicing/Tiling, Jerkiness

Our equipment unique here!

- Time to buffering
- Time to 1st picture
- Video download time

- Call statistics and session based KPIs

Video Streaming... Swissqual Test Equipment

Video applications in mobile testing

- Video Streaming – VoD incl, progressive download
- Video Streaming – live TV
- Video Telephony

Testing platforms

- PC client (UE as modem)
- User Equipment (Android)

Quality metrics

- Video MOS
- Freezing / Re-Buffering
- Spatial and temporal dimensions (PSNR, Blurriness, Blockiness, Slicing/Tiling, Jerkiness,...)
- Call statistics and session based KPIs

Algorithms

Full-reference VQuad / VQuad-HD	compares a reference video with an received video
No-reference VMon	evaluates a received video on its own
‚Hybrid‘ VMon-B	VMon but evaluating bitstream information
Freezing	evaluates a received video only for freezing/rebuffering
Bitstream models	predicts quality based on information of the bitstream

VQUAD HD
Precision in High Definition

VoLTE

The Voice over LTE, VoLTE scheme was devised as a result of operators seeking a standardised system for transferring voice traffic over LTE. Originally LTE was seen as a completely IP cellular system just for carrying data, and operators would be able to carry voice either by reverting to 2G / 3G systems or by using VoIP.

VoLTE Technology Status

- VoLTE is still in it's infancy, well, maybe grown a bit and in the teenage now!
- Still a lot of dynamics on the device side!

- …but we know how and what measure QUALITY !

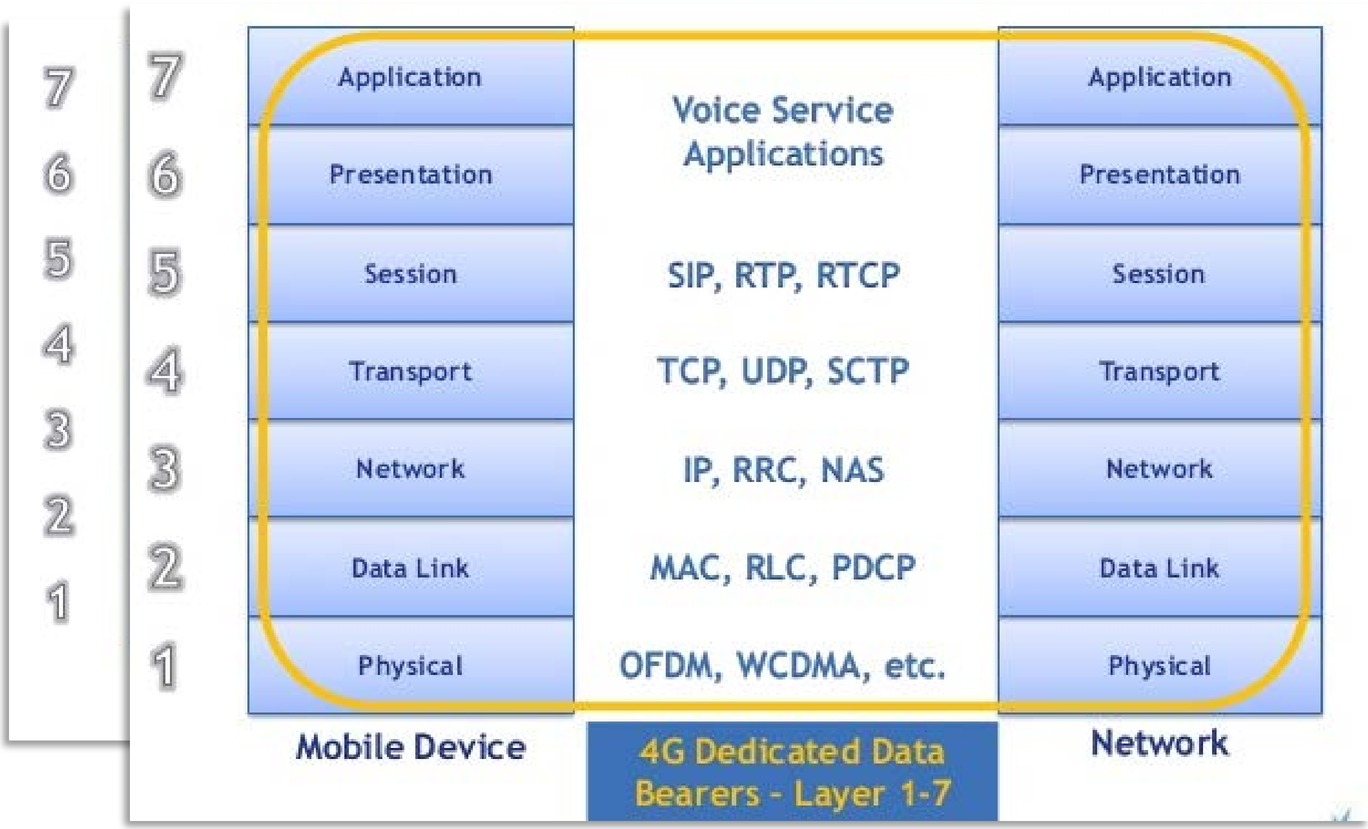
VoLTE

Key enablers od VoLTE fall into four categories

QoS	RAN	IMS	Codec
Dedicated vs. Non-Dedicated Bearers	Semi-persistent scheduling resource allocation	Session Initiation Protocol (SIP)	HD Voice (Wideband AMR)
Quality of Service Class Identifier (QCI)	Transmission Time Interval (TTI) Bundling	Policy and Charging Rules Function (PCRF)	
Dynamic Scheduler In ENodeB	Robust Header Compression (RoHC)	Real-time Transport Protocol (RTP)	
		Real-time Streaming (RTSP)	

VoLTE

Legacy Voice Service Depend on Robustness of Layers 1-3



4G Voice Service Depend on Robustness of ALL Layers !!!

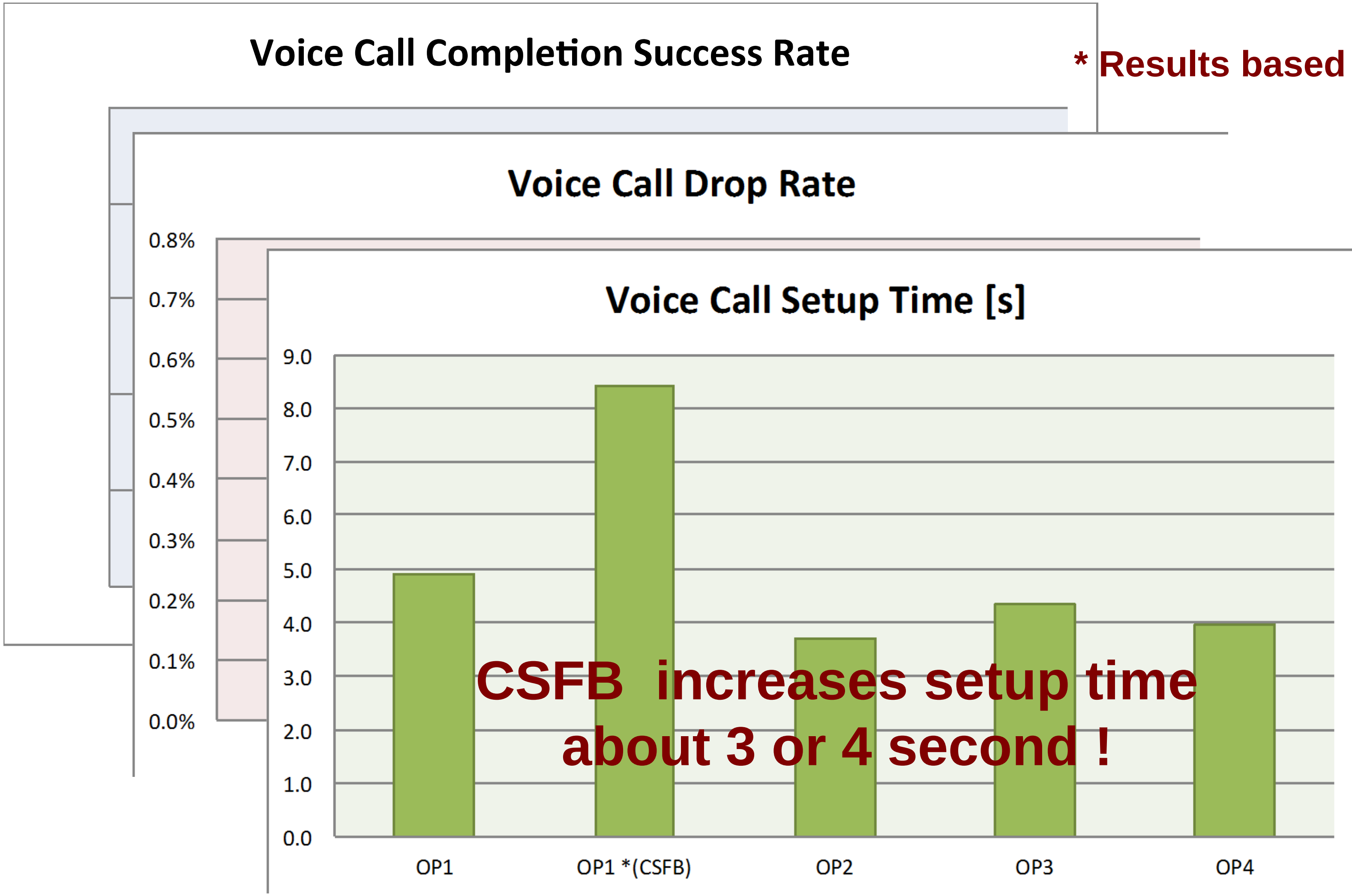
VoLTE

What we measure ?

End User Experience	KPI's
Ability to make and maintain calls	Call Initiation Rate (%), Call Drop Rate (%)
Time it takes for a phone to start ringing	Call Setup Time (s)
Speech quality during call	Mean Opinion Score (MOS)
Mouth-to-ear delay or latency variation during a call	Mouth-to-ear delay (s), Latency, Jitter

LTE - examples of results

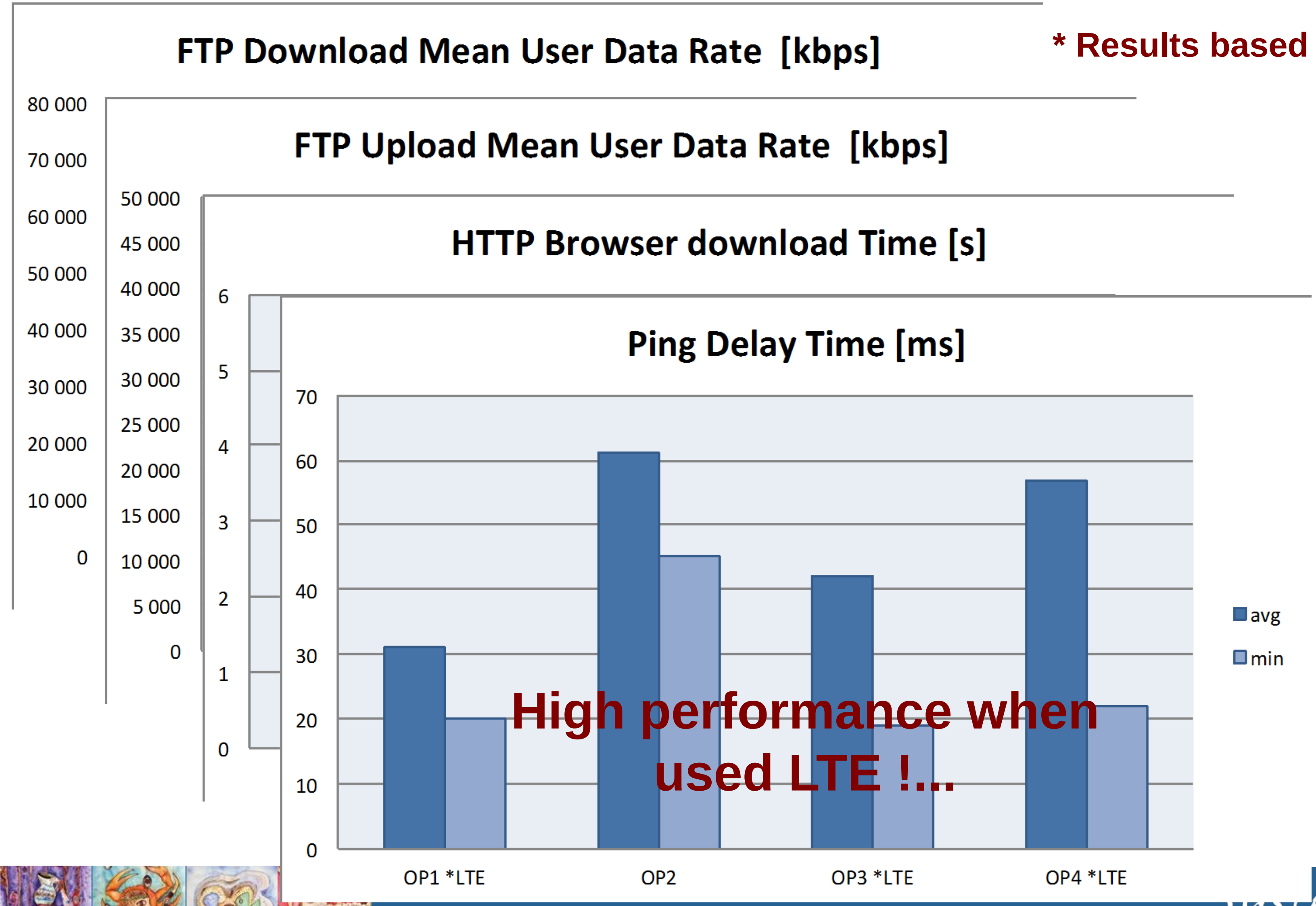
* Results based on Drive Test



CSFB increases setup time about 3 or 4 second !

LTE - examples of results

*** Results based on Drive Test**



Systemics PAB

LTE

СПАСИБО

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