How to Dimension User Traffic in 4G Networks

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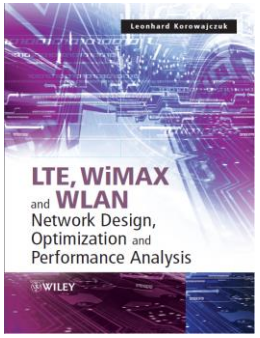
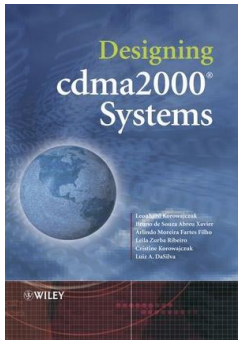
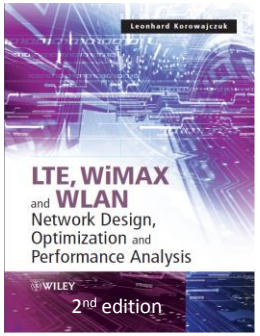
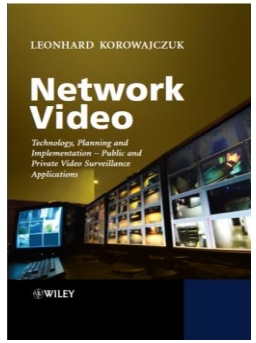
Presenter

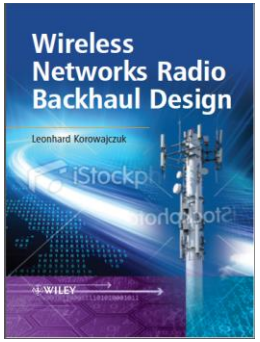
- **Leonhard Korowajczuk**
  - CEO/CTO CelPlan International
  - 45 years of experience in the telecom field (R&D, manufacturing and services areas)
  - Holds13 patents
  - Published books
    - "Designing cdma2000 Systems"
      - published by Wiley in 2006- 963 pages, available in hard cover, e-book and Kindle
    - "LTE , WiMAX and WLAN Network Design, Optimization and Performance Analysis "
      - published by Wiley in June 2011- 750 pages, available in hard cover, e-book and Kindle
  - Books in Preparation:
    - LTE , WiMAX and WLAN Network Design, Optimization and Performance Analysis
      - second edition (2014) LTE-A and WiMAX 2.1(1,000+ pages)
    - Network Video: Private and Public Safety Applications (2014)
    - Backhaul Network Design (2015)
    - Multi-Technology Networks: from GSM to LTE (2015)
    - Smart Grids Network Design (2016)

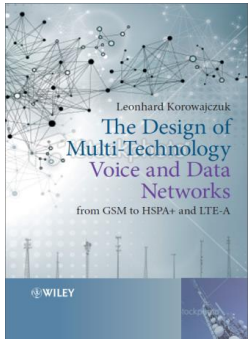












CelPlan International

- Employee owned enterprise with international presence
  - Headquarters in USA
  - 450 plus employees
  - Revenues of US$ 40M
  - Twenty (20) years in business
- Subsidiaries in 6 countries with worldwide operation
- Vendor Independent
- Network Design Software (CelPlanner Suite/CellDesigner)
- Network Design Services
- Network Optimization Services
- Network Performance Evaluation
- Services are provided to equipment vendors, operators and consultants
- High Level Consulting
  - RFP preparation
  - Vendor interface
  - Technical Audit
  - Business Plan Preparation
  - Specialized (Smart Grids, Aeronautical, Windmill, …)
- Network Managed Services
- 2G, 3G, 4G, 5G Technologies
- Multi-technology / Multi-band Networks
- Backhaul, Small cells, Indoor, HetNet, Wi-Fi offloading

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  - June 4th 2014
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  - August 6th2014
- **What LTE parameters need to be Dimensioned and Optimized?**
  - September 3rd 2014
- **Spectrum Analysis for LTE Systems**
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  - November 5th 2014
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Today's Topic

How to Dimension User Traffic in 4G Networks

How to Dimension User Traffic in 4G Networks

- Mobile user devices, connections and data consumption are expected to grow exponentially over the next few years
- Revenues from mobile subscriptions are decreasing while subscriber growth, demand and usage are increasing.
- At the same time, mobile operators are expected to ensure their networks are able to meet the increasing demand needed to safeguard their market share & revenue streams
- Most operators are looking at 4G as a natural evolution and a solution capable of meeting this exponential growth & traffic demand
- 4G network user traffic is defined by the application users will use and its dimensioning is essential for the design of 4G networks
  - Data speed
  - Data tonnage
  - Subscriber plans
  - Calculation of traffic per subscriber
  - Geographic and temporal traffic distribution

User Data Traffic

- A subscriber is an entity that has an account with an operator
- A subscription can be shared by several users
- The market trend is to associate a traffic tonnage to a subscription
  - The days of unlimited access are gone
- Traffic is application dependent
- Traffic is UE dependent: smartphones, tablets, modems, laptops (USB)
- Traffic has to be properly characterized for network dimensioning and parameterization
- Traffic varies between regions according to local conditions

How to Characterize Data Traffic

- Data speed
  - How fast a data packet is delivered
    - It is unidirectional
  - Usually expressed in Mbps or kbps
    - A kb has 1,000 bit and denotes data transfer capacity
  - Marketing claims speeds up to 250 Mbps
    - Average speeds vary between 1 Mbps and 250 kbps (considering 100 users per cell of which 10% are active)
  - Typical instantaneous speed (for a 10 MHz bandwidth) is 240 kbit/s
    - Counting from the moment the first bit of a packet is received until the last one is received
    - Queing time is not considered
- Data Tonnage
  - How much data is exchanged
    - Unless explicitly said it includes downloading and uploading of data
  - Usually expressed in GB/month, Mb/hour or kbps
    - A kB has 8*1,024 bit and denotes data storage capacity
  - Typical tonnage is 50 kbps (2GB per month)

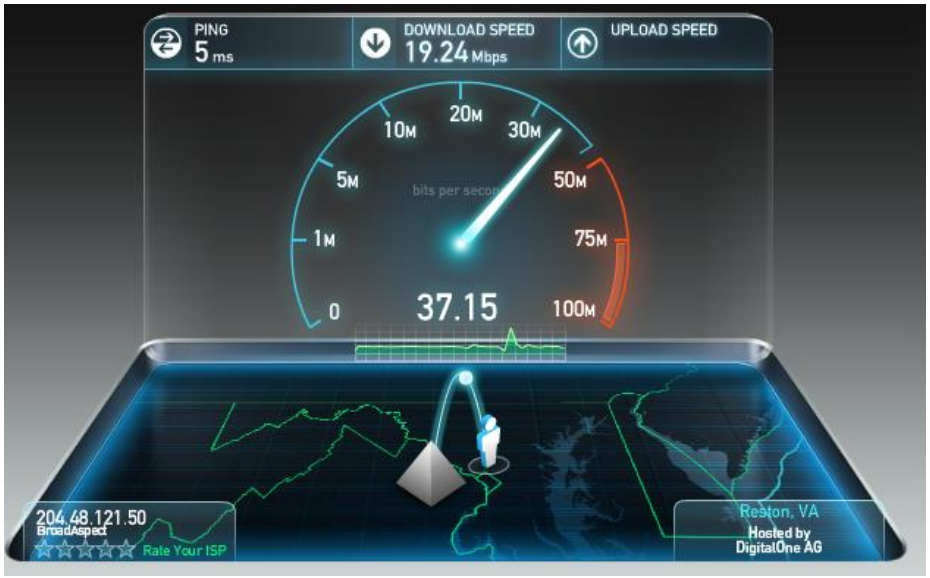
Data Speed Considerations

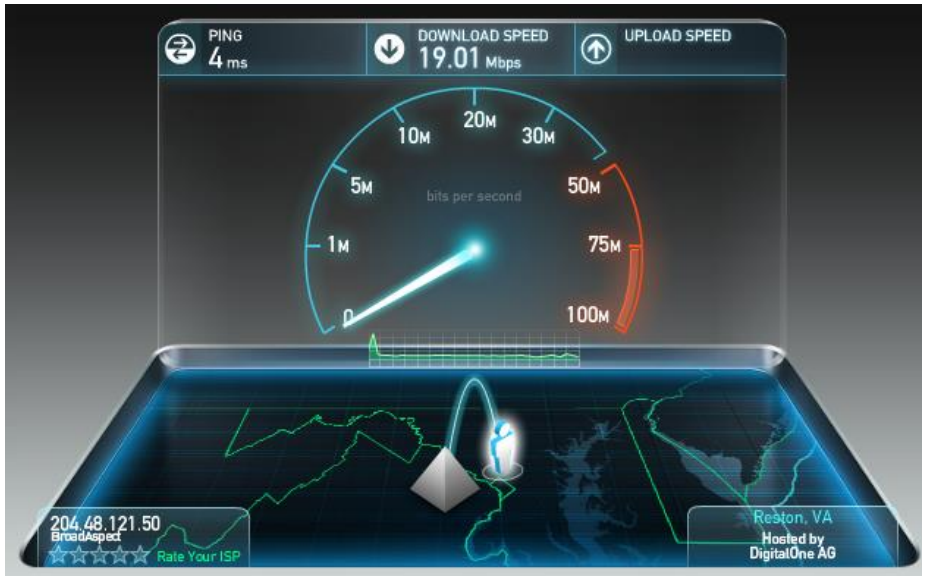
Data Speed Considerations

- Until recently the performance of data networks was specified by its instantaneous speed
- This is a misleading parameter, that was explored by marketers to advertise fantastic capabilities
- Advertised speeds were the maximum ones achieved in laboratories or in theory, with unloaded networks
- Speed meters only start measuring when the packet arrives, so they measure the instantaneous speed and do not consider waiting times
  - Speed meters measurements are in general proportional to the channel bandwidth
  - Speed drops with the number of users utilizing the network
- Deployed networks fell well below the advertised numbers and reality started to quick-in
- Networks should be evaluated in terms of their tonnage
- Speed can still be used as a secondary criteria.

Speed Test

- Measurement is made from the moment the packet reception begins, until the moment it ends
- A packet is mapped to an LTE TTI and send in its entirety
  - If more than one TTI is required, the packed is partitioned and send in subsequent TTIs
- The time the packet was in the queue waiting for other users to be transmitted is not considered
- Packet speed depends then on the channel bandwidth (available resources per TTI) and the load (numbe rof users sharing the resources)
  - An LTE FDD 10 MHz cell will have an instantaneous transfer data speed of 4 Mbit/s (QPSK) to 12 Mbit/s (64QAM)
    - The average instantaneous transfer speed will be around 5 Mbit/s
  - An LTE FDD 10 MHz cell average capacity is 5 Mbit/s, which has to be shared by all users. Assuming 20 active users, each user will have an average throughput (tonnage) of 250 kbps





3GPP TR 36.913 v11.0.0

3GPP TR 25.912.v.8.0.0; ITU-R M.2134

LTE FDD ITU (Release 8) Spectral Efficiency Objectives (bit/s/Hz)									
				Downlink			Uplink		
Scenario	Antennas	Inter-Site Distance (m)	Penetration Loss (dB)	Peak (bps/Hz)	Average (bps/Hz/cell)	Cell Edge 10 users per cell (bps/Hz/cell/user)	Peak (bps/Hz)	Average (bps/Hz/cell)	Cell Edge 10 users per cell (bps/Hz/cell/user)
3GPP Case 1 Carrier: 2 GHz Bandwidth: 10 MHz	1x2	500	20				3.75	0.86	0.028
	2x2			7.5	1.63	0.05			
	4x2			15	1.93	0.06			
	4x4				2.87	0.11			

LTE-A ITU Spectral Efficiency Objectives (bit/s/Hz)									
				Downlink			Uplink		
Scenario	Antennas	Inter-Site Distance (m)	Penetration Loss (dB)	Peak (bps/Hz)	Average (bps/Hz/cell)	Cell Edge 10 users per cell (bps/Hz/cell/user)	Peak (bps/Hz)	Average (bps/Hz/cell)	Cell Edge 10 users per cell (bps/Hz/cell/user)
ITU Indoor Hot Spot	4x2	60			3	0.1		2.25	0.07
	2x4								
ITU Urban Micro	4x2	200			2.6	0.075		1.8	0.05
	2x4								
ITU Urban Macro	4x2	500			2.2	0.06		1.4	0.03
	2x4								
ITU Rural Macro	4x2	1732			1.1	0.04		0.7	0.015
	2x4								
3GPP Case 1 Carrier: 2 GHz Bandwidth: 10 MHz	1x2	500	20					1.2	0.04
	2x4							2	0.07
	2x2				2.4	0.07			
	4x2				2.6	0.09			
	4x4				3.7	0.12	15		
	8x8			30					

3GPP TR 36.913 v11.0.0

3GPP TR 25.912.v.8.0.0; ITU-R M.2134

- The peak spectrum efficiency is the highest data rate normalised by overall cell bandwidth assuming error-free conditions, when all available radio resources for the corresponding link direction are assigned to a single UE.

- Average spectrum efficiency is defined as the aggregate throughput of all users (the number of correctly received bits over a certain period of time) normalized by the overall cell bandwidth divided by the number of cells. The average spectrum efficiency is measured in bps/Hz/cell

- The cell edge user throughput is defined as the 5% point of CDF of the user throughput normalized with the overall cell bandwidth. The calculations are done for 10 users randomly distributed.

3GPP LTE Data Speed

3GPP TR 36.913 v11.0.0								
3GPP TR 25.912.v.8.0.0; ITU-R M.2134								
	Antennas	Inter-Site Distance (m)	Downlink			Uplink		
			Peak (Mbps)	Average (Mbps/cell)	Cell Edge (Mbps/cell)	Peak (Mbps)	Average (Mbps/cell)	Cell Edge (Mbps/cell)
3GPP Case 1 Carrier: 2 GHz Bandwidth: 10 MHz	1x2	500					12	4
	2x2	500		24	7			
	8x8	500	300			150		

How to calculate user traffic?

Data Traffic = Data Tonnage

Typical Data Usage Plans

- Operators are shifting towards tonnage plans
- Subscriber pay for tonnage used
- Operators provide calculators for subscribers to estimate their requirements
  - Main services (applications) are listed
- Calculators estimate tonnage without qualification
- Network designer needs to qualify the traffic
- Traffic with similar characteristics can be bundled
- Bearers are virtual circuits that will carry user traffic and can be customized to the different types of traffic

Typical Monthly Plans (USA)

Smartphone		Typical usage	MB/month per unit
Email per day	How many e-mails you send and receive per day (text only)?	10 kB	0.2
Web access	How many web pages do you visit per day?	0.4 MB	30
Stream and download music	How many minutes do you spend streaming music files per day?	60 MB/hr	30
	How many music tracks do you download per month?	7 MB	7
Stream video	How many minutes do you spend streaming video per day? 3G	250 MB/hr	125
	How many minutes do you spend streaming video per day? 4G	350 MB/hr	175
Video calling	How many minutes do you spedn on video calling per day? Average bandwidth	480 MB/hr	240
	How many minutes do you spedn on video calling per day? High Bandwidth	720 MB/hr	360
Upload and download photos	How many photos do you download and upload per day?	3 MB	90
Navigation	How many minutes do you use turn by turn directions per day?	30 MB/hr	2.5

Tablet		Typical usage	MB/month per unit
Email per day	How many e-mails you send and receive per day (text only)?	10 kB	0.2
Web access	How many web pages do you visit per day?	1MB	30
Stream and download music	How many minutes do you spend streaming and downloading music files per day?	60 MB/hr	30
Stream video	How many minutes do you spend streaming video per day? Standard definition	650 MB/hr	325
	How many minutes do you spend streaming video per day? High definition	1 GB/hr	512
Video calling	How many minutes do you spedn on video calling per day?	150 MB/hr	755
Upload and download photos	How many photos do you download and upload per day?	5 MB	150
4G VoIP	How many minutes do you speak with video on an Internet protocol network per day?	30 MB/hr	15
4G VoIP with Video	How many minuted do you speak on an Internet protocol network per day?	425 MB/hr	212

Typical Monthly Plans (USA)

USB Device		Typical usage	MB/month per unit
Email per day	How many e-mails you send and receive per day (text only)?	10 kB	0.2
Web access	How many web pages do you visit per day?	1MB	30
Stream and download music	How many minutes do you spend streaming and downloading music files per day?	60 MB/hr	30
Stream video	How many minutes do you spend streaming video per day? Standard definition	650 MB/hr	325
	How many minutes do you spend streaming video per day? High definition	2 GB/hr	1024
Upload and download photos	How many photos do you download and upload per day?	5 MB	150
4G VoIP	How many minuted do you speak on an Internet protocol network per day?	45 MB/hr	212
4G VoIP with Video	How many minutes do you speak with video on an Internet protocol network per day?	260 MB/hr	130
Online gaming	How many minutes do you speak on an Internet protocol network per day?	5 MB/hr	2.5

Internet Connected Device (Broadband Router)		Typical usage	MB/month per unit
Email per day	How many e-mails you send and receive per day (text only)?	10 kB	0.2
Web access	How many web pages do you visit per day?	1MB	30
Stream and download music	How many minutes do you spend streaming and downloading music files per day?	51 MB/hr	26
Stream video	How many minutes do you spend streaming video per day? Standard definition	500 MB/hr	250
	How many minutes do you spend streaming video per day? High definition	1.68 GB/hr	860
Upload and download photos	How many photos do you download and upload per day?	5 MB	150
4G VoIP	How many minutes do you speak with video on an Internet protocol network per day?	67 MB/hr	34
4G VoIP with Video	How many minutes do you speak on an Internet protocol network per day?	254 MB/hr	127

Typical Monthly Plans (USA)

	Monthly access (US$) per individual	700 min voice per individual (US$)	Unlimited voice and text per individual (US$)	Price in US$															
Data allowance (GB/month)				0.25	0.5	1	2	3	4	6	8	10	12	14	16	18	20	30	40	50
Basic Phone	30	5	40	15	30	40	50	60	30	40	50	60	70	80	90	100	110	185	260	335
Smartphone	40		40	15	30	40	50	60	30	40	50	60	70	80	90	100	110	185	260	335
Tablet	10								30	40	50	60	70	80	90	100	110	185	260	335
Connected Device (USB)	5								30	40	50	60	70	80	90	100	110	185	260	335
Internet Device (modem)	20								30	40	50	60	70	80	90	100	110	185	260	335

Overage per1 GB US$	15

- Average user: 1 to 2GB per device

Price per GB/month US$)	$ 6.00
Cell Capacity per month (GB)	13,824
Revenue per month for a fully loaded 10 MHz cell (US$)	$ 82,944.00

How to transform monthly tonnage into kbps

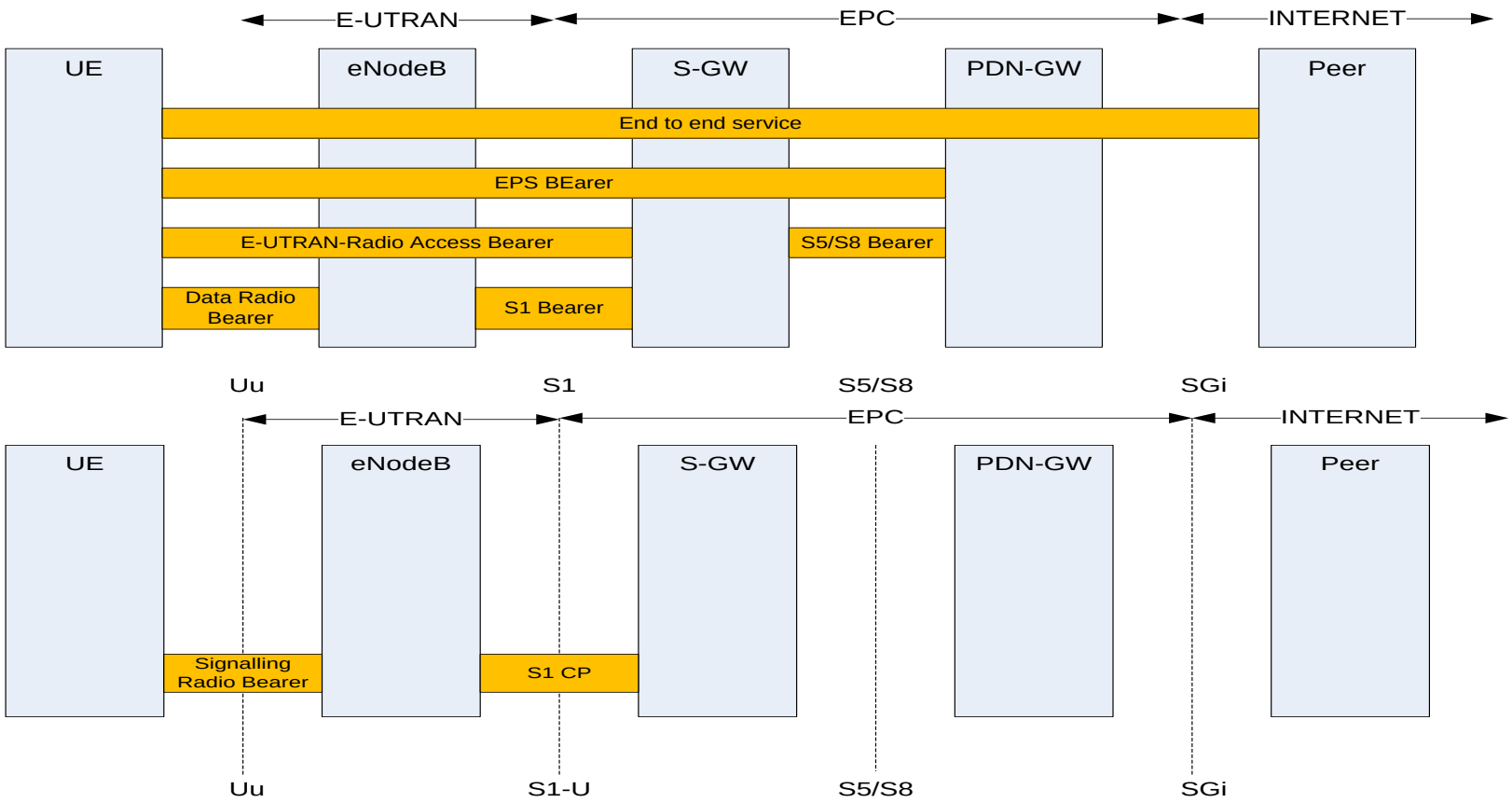
- Let's start with a 1 GB/ month
- First we consider that the usage is uniform over the days
  - This is valis in average, but is not precise
  - 1 GB/month =33.33 MB/day
- Part of the daily traffic is concentrated in the Busy Hour
  - Our measurements indicate a factor of 1/3, as an average in our deployments
  - 33.33 MB/day = 11.11 MB/busyhour
- We can then calculate the average per second
  - 11.11 MB/busyhour= 3.08 KBps
- Finally we conver Bytes to bits
  - 3.08 KBps= 3.08*1.024*8= 25.2839bps

Bearers

Virtual Connections in a Packet Network

Bearers

- An EPS (Evolved Packet System) Bearer has to be established between the UE and its Peer in the outside network
  - It is a logical connection that has an origin and a destination
  - It specifies how the information should be handled by the network in terms of quality and priority
- This Bearer information is carried by specific bearers between the other entities



Bearers

- A bearer is a carrier of information
  - It is a logical connection that has an origin and a destination
  - It specifies how the information should be handled by the network in terms of quality and priority
- In packet switching, once established a bearer provides a virtual always on connection
- Once an UE connects to an eNodeB, it is assigned an non-GBR bearer, which provides the always on connectivity
- An UE may be running multiple applications that require different QoS (Web, video, VoIP)
- An UE can have up to 3 SBR (Signalling Bearers) and up to 8 DBR (Data Bearers) assigned (numbered 0 to 10)
- A dedicated bearer is established for each QoS level required by the UE
  - SRB0- Signaling Radio Bearer 0- RRC messages over CCCH. It is used for RRC connection request, Reject, Reestablishment, Reestablishment request and Reestablishment reject
  - SRB1- Signaling Radio Bearer 1- NAS (Non-Access Stratum) messages over the DCCH, uses acknowledged mode
  - SRB2- Signaling Radio Bearer 2- high priority RRC messages over DCCH, uses acknowledged mode
  - Data bearers- identified by DRB (Data Radio Bearer), numbered from 1 to 11

3 GPP Bearers QoS

- Bearer is a virtual connection in a packet network, equivalent to a connection in a circuit network, but with pre defined performance
  - It is a logical connection that has an origin and a destination
  - It specifies how the information should be handled by the network in terms of quality and priority
  - Defined in 3GPP 36.300
  - GBR- Guaranteed Bit Rate (a specific data tonnage is specified)
  - Non-Guaranteed Bit Rate (a maximum data tonnage per period is specified)
  - QCI- Quality of Service (QoS) Class identifier
  - ARP- Allocation and Retention priority
  - Aggregate Bit Rate is equivalent to the total tonnage over a period of time for all no-GBR bearers
- Bearer definition is equivalent to a service definition
- Bearers are unidirectional
  - Downlink and Uplink can use bearers with different QoS

Evolved Radio Access Bearer (E- RAB)	**GBR**	**Non-GBR**
QoS Class Identifier (QCI)	x	x
Allocation and Retention Priority (ARP)	x	x
Guaranteed Bit Rate (GBR)	x	
Maximum Bit Rate (MBR)	x	
Access Point Name (APN) Aggregate Maximum Bit Rate (APN-AMBR)		x
UE Aggregate Maximum Bit Rate (UE-AMBR)		x

Quality of Service (QoS)

- Quality of Service (QoS)
  - QoS Class Identifier (QCI)
    - GBR/NGBR
    - Priority (1 to 9)
    - Packet Delay Budget
    - Packet Error Loss Rate
  - Allocation and Retention Priority (ARP)
    - Preemption capability
    - Preemption vulnerability
    - Preemption Priority (1 to 15)
  - GBR
  - MBR
  - Access Point Name- Aggregate Maximum Bit Rate (APN-AMBR)
  - User Equipment- Aggregate Maximum Bit Rate (UE-AMBR)
- Service Characteristics
  - Tonnage
  - Average Packet Size
  - Average Delay

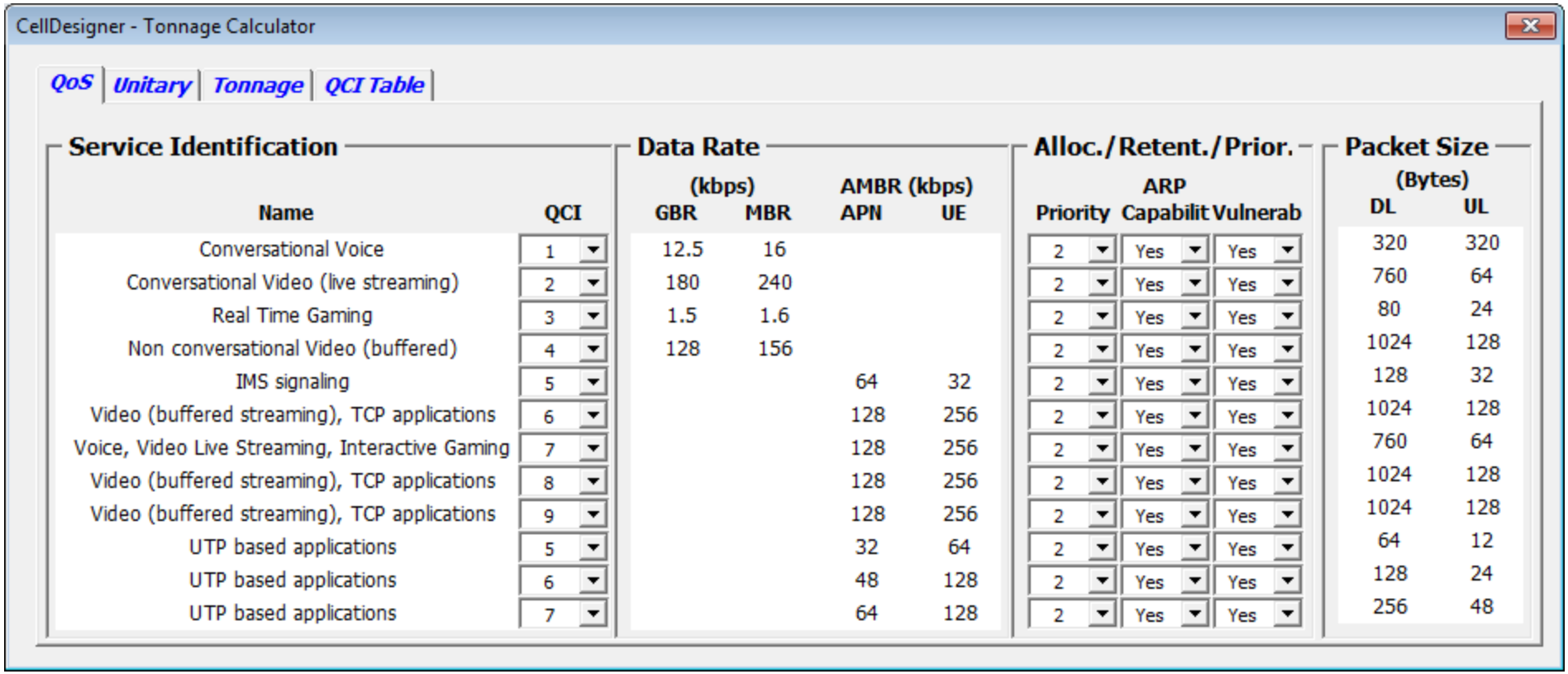
3 GPP QoS Class Identifier (QCI) Categories

- GBR (Guaranteed Bit Rate) is a service that requires a minimum tonnage
- Non-GBR (Non Guaranteed Bit Rate) is a service that has no minimum tonnage requirement
- PER (Packet Error Rate) defined for each service, which is obtained after HARQ (PHY) and ARQ (MAC and RLC) retransmissions
- MBR (Maximum Bit Rate) is the maximum tonnage that should be offered to a GBR service
- Packet Delay Budget is the delay between the UE and the Policy and Charging Enforcement Function (PCEF) within the Packet Data Network (PDN) gateway. It represents mainly the delay between the eNB and UE
- Aggregate Maximum Bit Rate is the aggregate tonnage over a period of time, that limits the maximum that a user can transmit or receive over the period of time

QoS Class Identifier (QCI)	Services examples	Resource Type	Priority (1 highest)	Packet Delay Budget- PDB (ms)	Packet Error Loss Rate (PER)	GBR (kbps)	MBR (kbps)	APN-AMBR (kbps)	UE-AMBR (kbps)
1	Conversational Voice	GBR	2	100	10^{-2}	12	12		
2	Conversational Video (live streaming)		4	150	10^{-3}	180	240		
3	Real Time Gaming		3	50	10^{-3}	1.5	1.6		
4	Non-conversational Video (buffered streaming)		5	300	10^{-6}	120	140		
5	IP Multimedia Sub-system (IMS) Signalling	Non-GBR	1	100	10^{-6}	-	-	64	32
6	Video (buffered streaming) TCP based (www, e-mail, chat, ftp, p2p, progressive video,..)		6	300	10^{-6}	-	-	128	64
7	Voice, Video (live streaming), Interactive Gaming		7	100	10^{-3}	-	-	256	128
8	Video (buffered streaming) TCP based (www, e-mail, chat, ftp, p2p, progressive video,..)		8	300	10^{-6}	-	-	512	256
9			9	300	10^{-6}	-	-	512	256

Tonnage Calculator

- Bearer QoS



Tonnage Calculator

- Unitary Daily Tonnage per terminal

CellDesigner - Tonnage Calculator

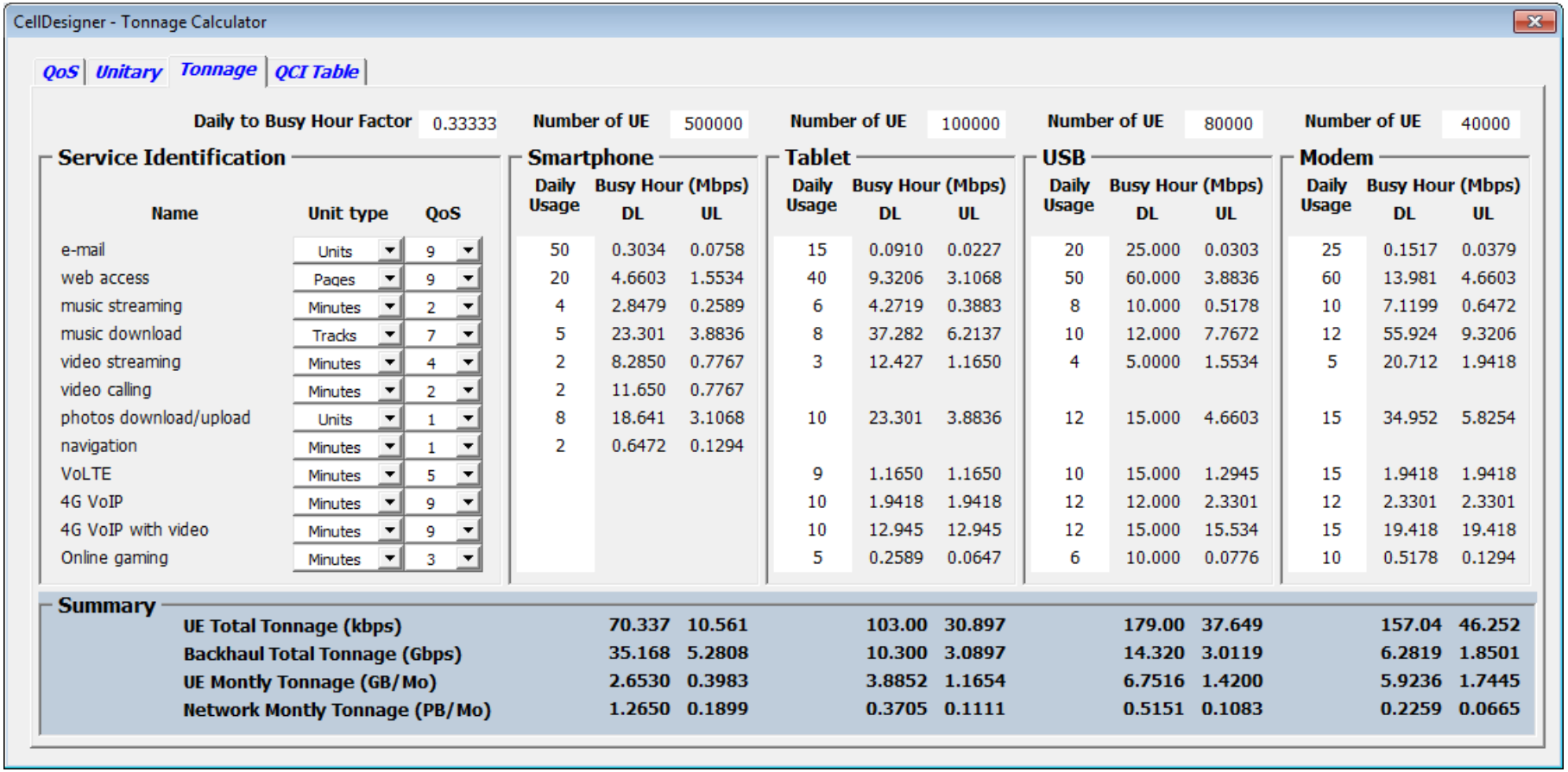
QoS | Unitary | Tonnage | QCI Table

Unitary Daily Tonnage

Service Identification		Smartphone		Tablet		USB		Modem	
Name	Unit type	DL	UL	DL	UL	DL	UL	DL	UL
e-mail	kB	2	8	2	8	2	8	2	8
web access	MB	0.1	0.3	0.1	0.3	0.1	0.3	0.1	0.3
music streaming	MB/h	5	55	5	55	5	55	5	55
music download	MB	1	6	1	6	1	6	1	6
video streaming	MB/h	30	320	30	320	30	320	30	320
video calling	MB/h	30	450	30	450	30	450	30	450
photos download/upload	MB	0.5	3	0.5	3	0.5	3	0.5	3
navigation	MB/h	5	25	5	25	5	25	5	25
VoLTE	MB/h	10	10	10	10	10	10	10	10
4G VoIP	MB/h	15	15	15	15	15	14	15	15
4G VoIP with video	MB/h	100	100	100	100	100	100	100	100
Online gaming	MB/h	1	4	1	4	1	4	1	4

Tonnage Calculator

- Busy Hour tonnage per type of terminal



CellDesigner - Tonnage Calculator

QoS | Unitary | Tonnage | QCI Table

Daily to Busy Hour Factor: 0.33333

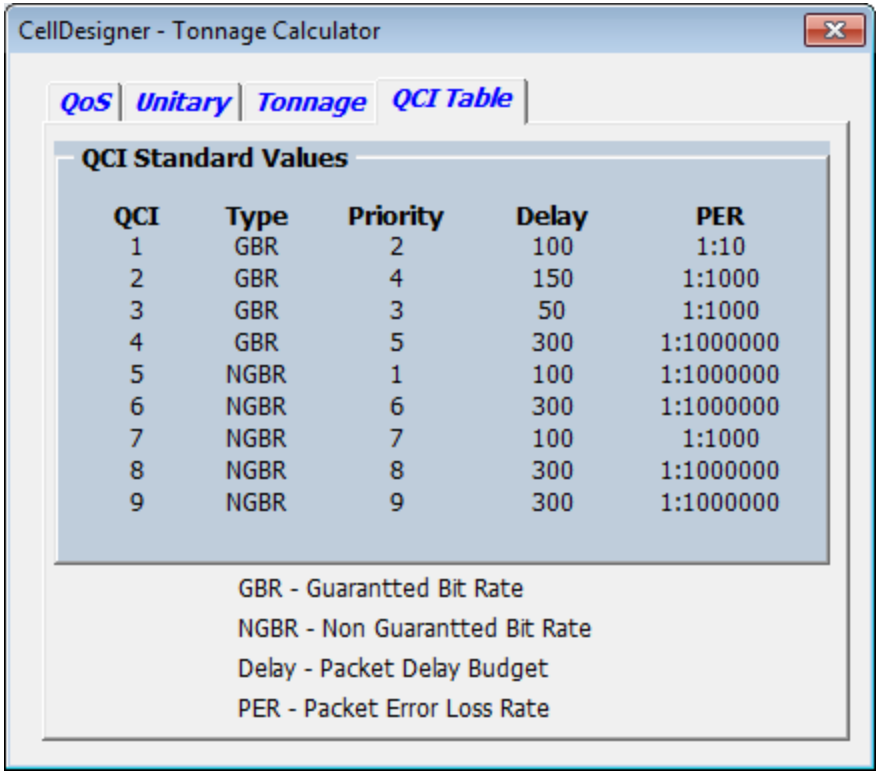
Service Identification			Smartphone			Tablet			USB			Modem		
Name	Unit type	QoS	Number of UE: 500000			Number of UE: 100000			Number of UE: 80000			Number of UE: 40000		
			Daily Usage	Busy Hour (Mbps) DL	UL	Daily Usage	Busy Hour (Mbps) DL	UL	Daily Usage	Busy Hour (Mbps) DL	UL	Daily Usage	Busy Hour (Mbps) DL	UL
e-mail	Units	9	50	0.3034	0.0758	15	0.0910	0.0227	20	25.000	0.0303	25	0.1517	0.0379
web access	Pages	9	20	4.6603	1.5534	40	9.3206	3.1068	50	60.000	3.8836	60	13.981	4.6603
music streaming	Minutes	2	4	2.8479	0.2589	6	4.2719	0.3883	8	10.000	0.5178	10	7.1199	0.6472
music download	Tracks	7	5	23.301	3.8836	8	37.282	6.2137	10	12.000	7.7672	12	55.924	9.3206
video streaming	Minutes	4	2	8.2850	0.7767	3	12.427	1.1650	4	5.0000	1.5534	5	20.712	1.9418
video calling	Minutes	2	2	11.650	0.7767									
photos download/upload	Units	1	8	18.641	3.1068	10	23.301	3.8836	12	15.000	4.6603	15	34.952	5.8254
navigation	Minutes	1	2	0.6472	0.1294									
VoLTE	Minutes	5				9	1.1650	1.1650	10	15.000	1.2945	15	1.9418	1.9418
4G VoIP	Minutes	9				10	1.9418	1.9418	12	12.000	2.3301	12	2.3301	2.3301
4G VoIP with video	Minutes	9				10	12.945	12.945	12	15.000	15.534	15	19.418	19.418
Online gaming	Minutes	3				5	0.2589	0.0647	6	10.000	0.0776	10	0.5178	0.1294

Summary

	Smartphone		Tablet		USB		Modem	
UE Total Tonnage (kbps)	70.337	10.561	103.00	30.897	179.00	37.649	157.04	46.252
Backhaul Total Tonnage (Gbps)	35.168	5.2808	10.300	3.0897	14.320	3.0119	6.2819	1.8501
UE Montly Tonnage (GB/Mo)	2.6530	0.3983	3.8852	1.1654	6.7516	1.4200	5.9236	1.7445
Network Montly Tonnage (PB/Mo)	1.2650	0.1899	0.3705	0.1111	0.5151	0.1083	0.2259	0.0665

Tonnage Calculator

- QCI table



Bearer Classes

- Operator defines several Bearers and matches them to Internet Protocol requirements
- Some parameters are required by the Evolved packet Core (EPC), others are required for simulation

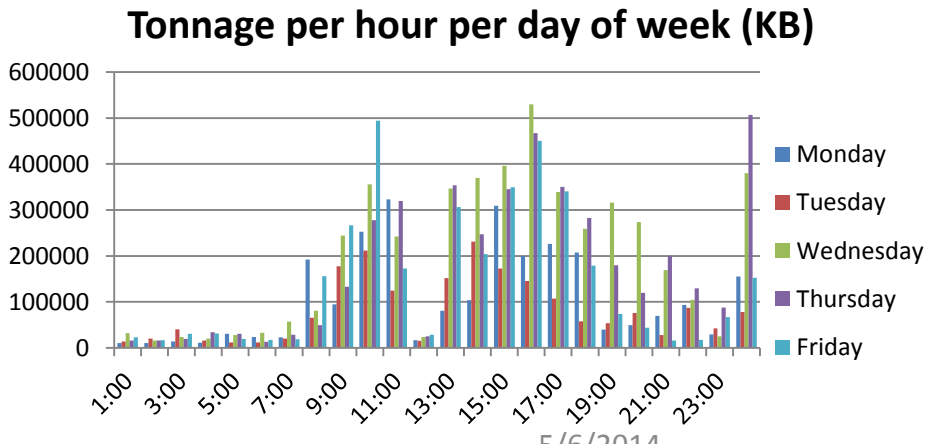
Quality of Service- QoS														Packet Size		Use Description/ Protocol	Typical Associated Protocols
Class	QoS Class Identifier (QCI)										ARP						
	Type	GBR	NGBR	Priority	Delay Budget (ms)	Packet Loss (PER)	GBR (kbit/s)	MBR (kbit/s)	UE-AMBR (kbit/s)	APN-AMBR (kbit/s)	Preemption vulnerability	Preemption capability	Priority	Downlink (KB)	Uplink (kB)		
1	1	y	-	2	100	10^{-2}	12.5	16	-	-	N	Y	1	320	320	Conversational Voice	UDP, SIP, VoIP
2	2	y	-	4	150	10^{-3}	180	240	-	-	N	Y	2	760	760	Conversational Video (live streaming)	UDP, RTSP
3	3	y	-	3	50	10^{-3}	1.5	1.6	-	-	N	Y	3	80	80	Real Time Gaming	UDP, RTP
4	4	y	-		300	10^{-6}	128	156	-	-	N	Y	4	1024	128	Conversational Video (hi-definition)	UDP, RSTP
5	5	-	y	51	100	10^{-6}	-	-	64	32	Y	Y	5	128	32	IMS signaling	TCP, RTP
6	6	-	y	6	300	10^{-6}	-	-	128	256	Y	Y	5	1024	128	Video (buffered streaming), TCP applications	TCP, FTP
7	7	-	y	7	100	10^{-3}	-	-	128	256	Y	Y	6	760	64	Voice, Video Live Streaming, Interactive Gaming	TCP, HTTP, VoIP
8	8	-	y	8	300	10^{-6}	-	-	128	256	Y	Y	6	1024	128	Video (buffered streaming), TCP applications	TCP, SMPTP, POP
9	9	-	y	9	300	10^{-6}	-	-	128	256	Y	Y	8	1024	128	Video (buffered streaming), TCP applications	TCP, FTP, IMAP
10	5	-	y	9	300	10^{-7}	-	-	32	64	Y	N	15	64	12	UDP based applications	UDP, SNMP
11	6	-	y	9	300	10^{-8}	-	-	48	128	Y	N	14	128	24	UDP based applications	UDP, SMTP,POP
12	7	-	y	9	300	10^{-9}	-	-	64	128	Y	N	13	256	48	UDP based applications	UDP, RTP
13	8	-	y	9	300	10^{-10}	-	-	76	128	Y	N	11	512	96	UDP based applications	UDP
14	9	-	y	9	300	10^{-11}	-	-	88	128	Y	N	9	1024	192	UDP based applications	UDP, RTP
15	1	y	-	2	100	10^{-2}	7.5	8	64	128	Y	N	1	240	240	UDP based applications	UDP, SIP, VoIP

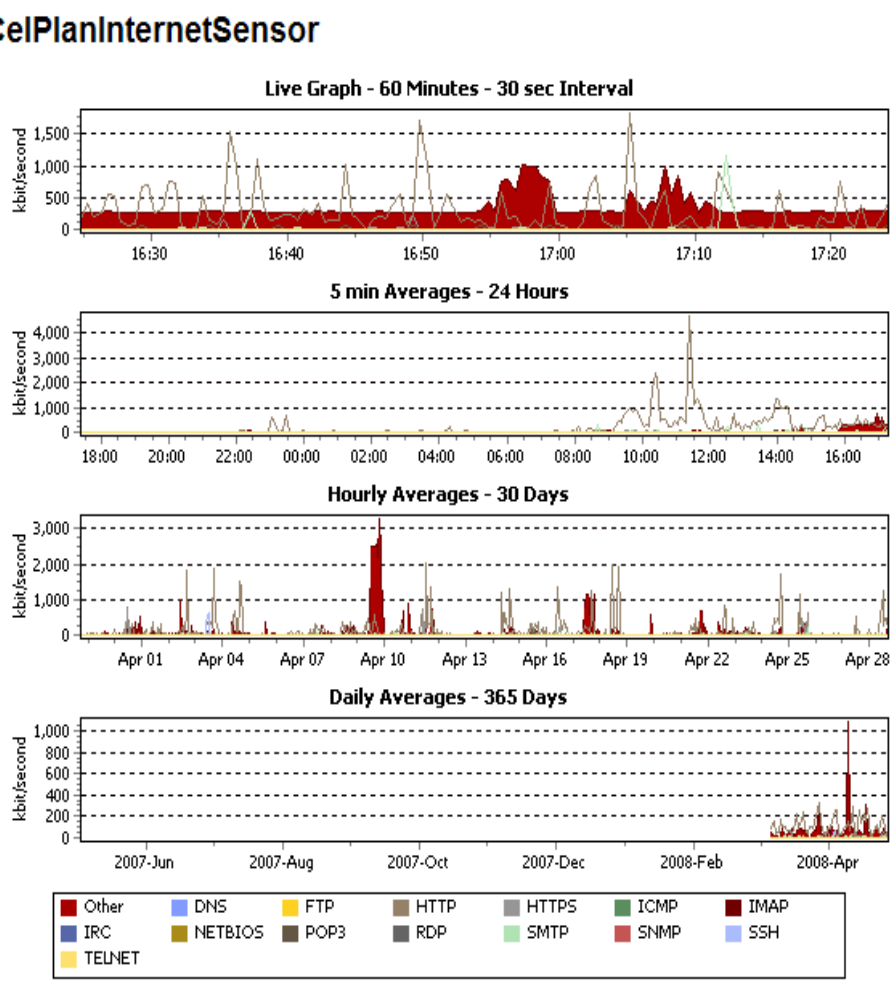
User Applications Determination

User Applications

- Typical user data traffic can be captured to provide indications of tonnage and its distribution per protocol
  - Network Monitor Utility example: PRTG Network monitor

Protocol	max KB	average kB	min KB
HTTP	38,063	3,085	148
Other	27,056	1,575	74
POP3	23,046	332	53
SMTP	9,166	411	7
HTTPS	2,928	199	43
NETBIOS	473	25	1
DNS	61	11	0
ICMP	36	17	12
SSH	17	0	-
SNMP	10	2	1
RDP	2	0	-
FTP	0	0	-
IRC	0	0	-
IMAP	-	-	-
TELNET	-	-	-
Sum	39,519	5,637	546





User Applications

- Major network applicationss used in the network have to be identified
- QoS should be assigned to each service, so the type of bearer is characterized
- Additional technical parameters have to be assigned to each service

	SERVICE	Unit	Smartphone					Tablet					USB					Modem					QoS
			Unitary average				BH tonnage per UE (kbit/s)	Unitary average				BH tonnage per UE (Mbit/s)	Unitary average				BH tonnage per UE (Mbit/s)	Unitary average				BH tonnage per UE (Mbit/s)	
			Quanity per day	Down	Up	Unit		Quantity per day	Down	Up	Unit		Quanity per day	Down	Up	Unit		Quanity per day	Down	Up	Unit		
1	E-mail	unit	5	8	2	kB	0.04	15	8	2	kB	0.11	20	8	2	kB	0.15	25	8	2	kB	0.19	9
2	Web access	page	20	0.3	0.1	MB	6.21	40	0.3	0.1	MB	12.43	50	0.3	0.1	MB	15.53	60	0.3	0.1	MB	18.64	9
3	Music streaming	minute	4	55	5	MB/hr	3.1	6	55	5	MB/hr	4.7	8	55	5	MB/hr	6.2	10	55	5	MB/hr	7.8	2
4	Music download	track	5	6	1	MB	27.19	8	6	1	MB	43.50	10	6	1	MB	54.37	12	6	1	MB	65.24	7
5	Video streaming	minute	2	320	30	MB/hr	9.1	3	320	30	MB/hr	13.6	4	320	30	MB/hr	18.1	5	320	30	MB/hr	22.7	4
6	Video calling	minutes	2	450	30	MB/hr	12.4	-	-	-			-	-	-			-	-	-			2
7	Photos download/upload	unit	8	3	0.5	MB	21.75	10	3	0.5	MB	27.19	12	3	0.5	MB	32.62	15	3	0.5	MB	40.78	1
8	Navigation	minute	2	25	5	MB/hr	0.8	-	-	-			-	-	-			-	-	-			1
9	VoLTE	minute	-	-	-			9	10	10	MB/hr	2.3	10	10	10	MB/hr	2.6	15	10	10	MB/hr	3.9	5
10	4G VoIP	minute	-	-	-			10	15	15	MB/hr	3.9	12	14	15	MB/hr	4.5	12	15	15	MB/hr	4.7	9
11	4G VoIP with video	minute	-	-	-			10	100	100	MB/hr	25.9	12	100	100	MB/hr	31.1	15	100	100	MB/hr	38.8	9
12	Online gaming	minute	-	-	-			5	4	1	MB/hr	0.3	6	4	1	MB/hr	0.4	10	4	1	MB/hr	0.6	3
UE Tonnage per BH		kbit/s					80.6					133.9					165.6					203.3	
UE Tonnage per month		GB/month					3.0					5.1					6.2					7.7	
Quantity in Network		users	500,000					100,000					80,000					40,000					
Network Tonnage		PB/month					1.4					0.5					0.5					0.3	
Total Network Tonnage		PB/month	2.7																				

User Distribution

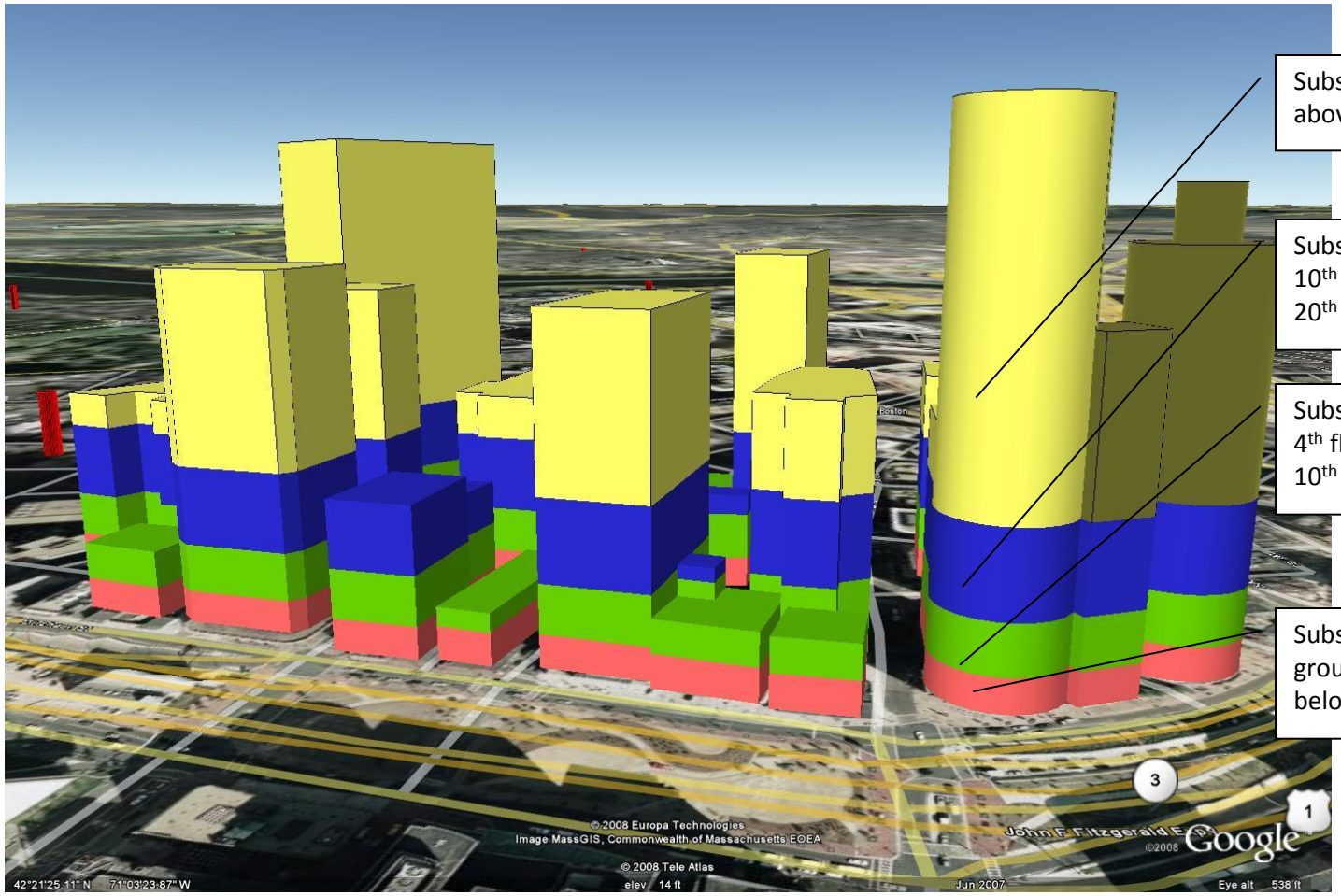
Time and Geographic Distribution of Users

Geographic Distribution of Users

- Users are not distributed uniformly across the service area
- Service area can be divided in regions according to its purpose (e.g. commercial, residential, mixed).
- Each region does have its peak load of users, which should be mapped on a pixel basis
- Users should be distributed across the region according to its morphology (clutter)
- The area of building floors should be considered in the region area, when doing user distribution
- The total number of users across all regions will be in general larger than the total number of users in the network

Geographical Traffic Distribution

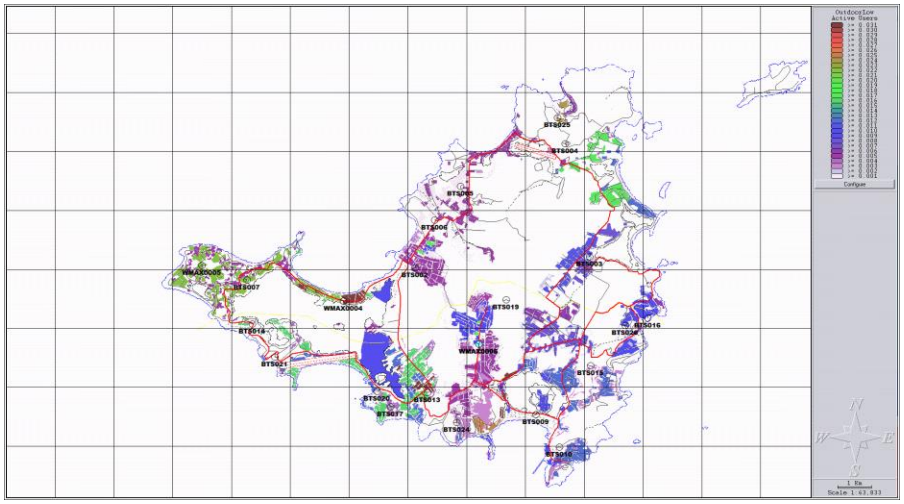
- Traffic should be distributed at different heights



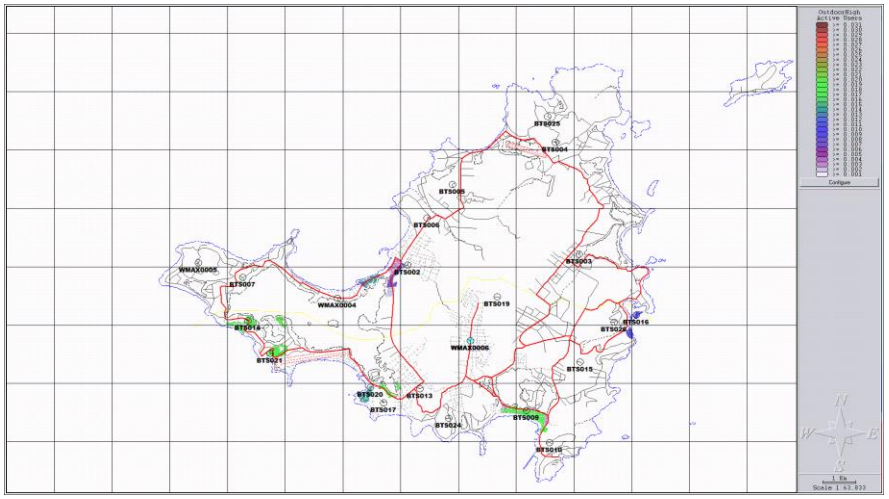
Geographical Traffic Distribution

- Traffic should be distributed geographically

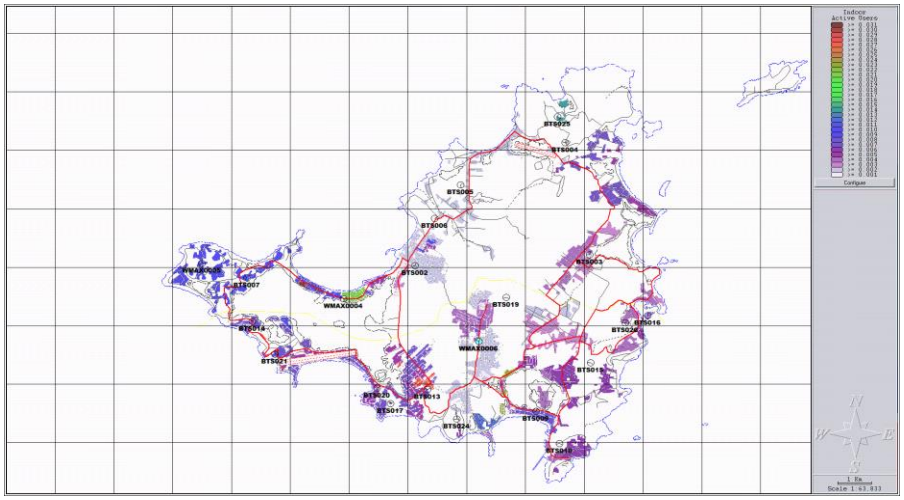
Indoor 4.5 m



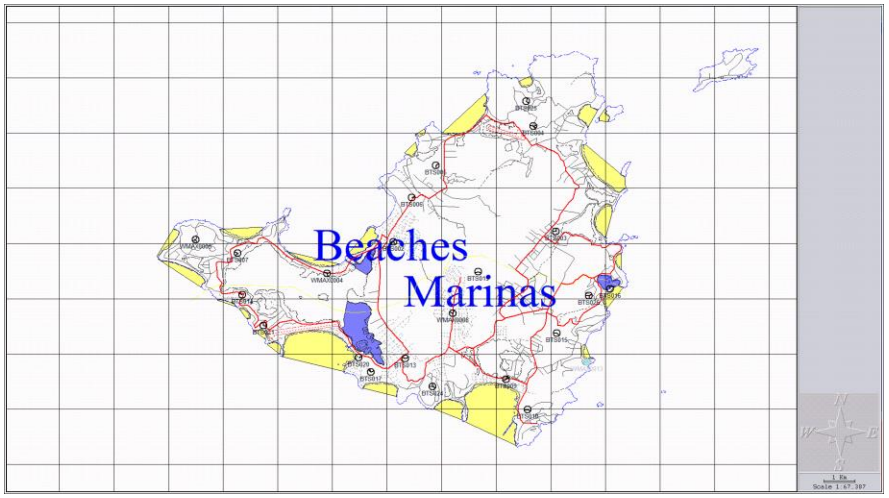
Indoor 10.5 m



Outdoor



Marinas and Beaches

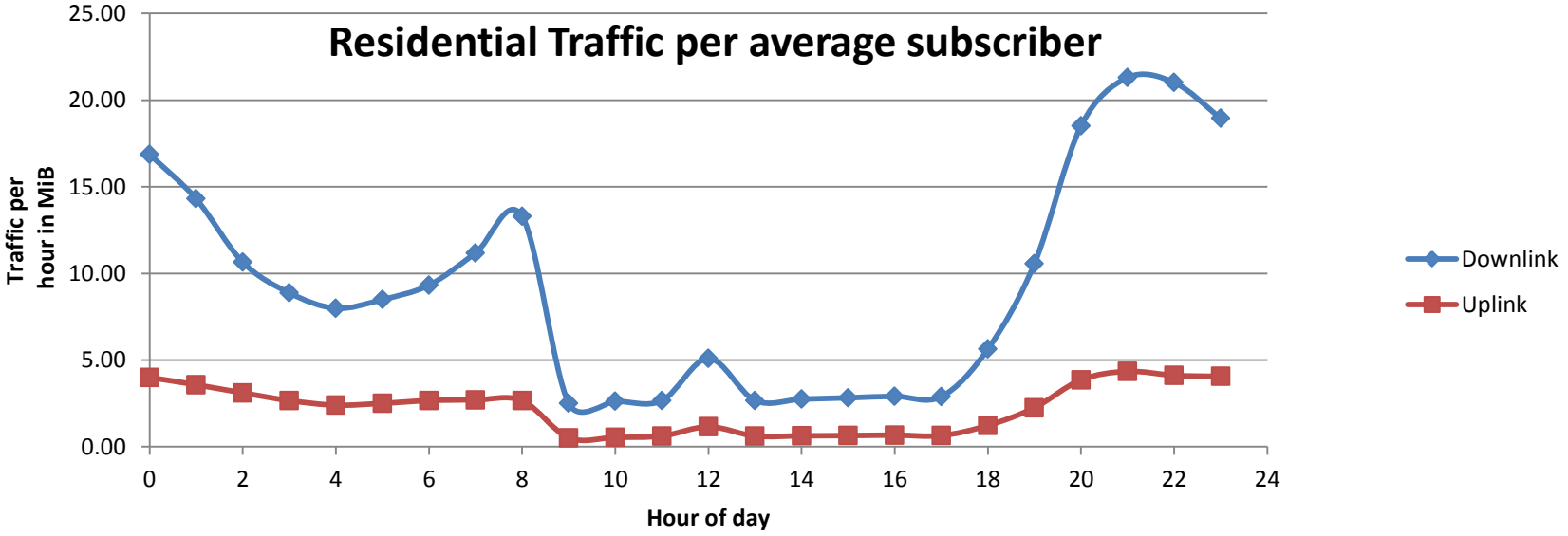


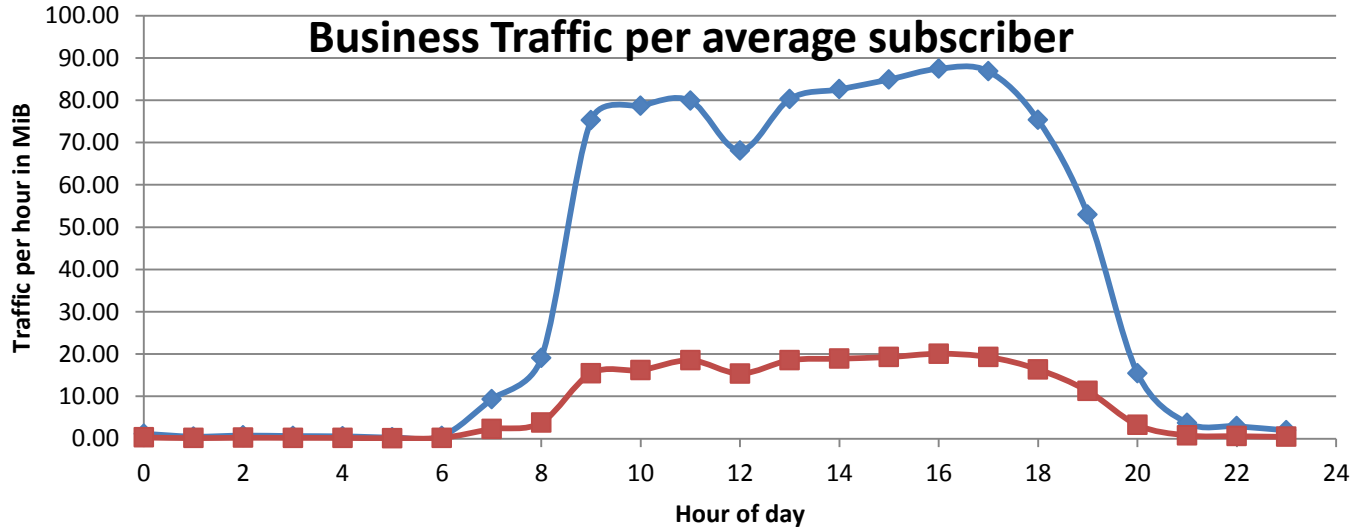
Temporal Distribution of Users

- Regions were specified for the peak number of users
- This number will then vary with the hour of the day and this can be reflected in a curve
- This allows to have to obtain users distribution according to the hour of the day
- Care should be taken that the aggregated number of users across all regions does not pass the total number of users in the network
  - Using a curve with the number of inactive users (away from the phone) per hour of the day helps to populate the curves properly

Temporal Traffic Distribution

- Different hours of the day can be simulated by applying hourly factors



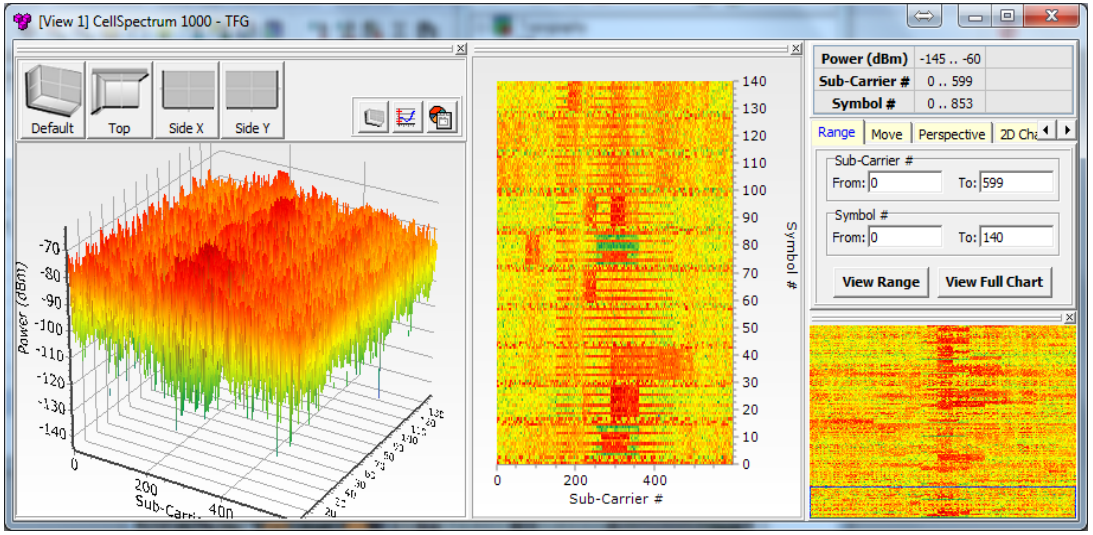


CelPlan New Products

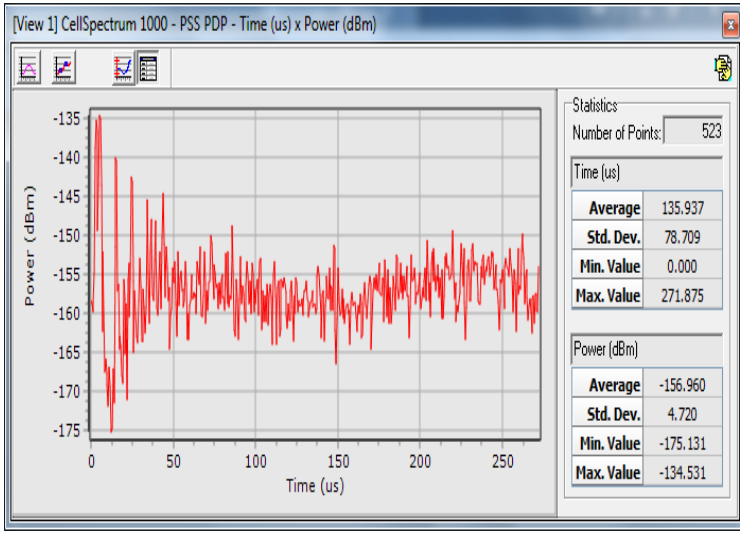
CellSpectrum

- A unique spectrum scanner for LTE channels
- Presents measurements in 1D (dimension), 2D and 3D at RE (Resource Element) level

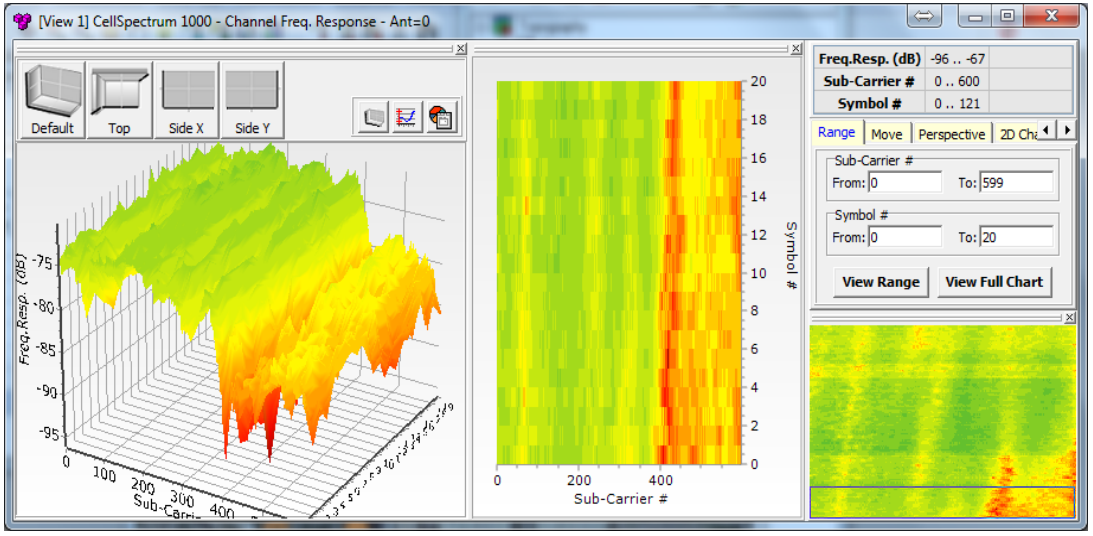
Received Signal level



Multipath



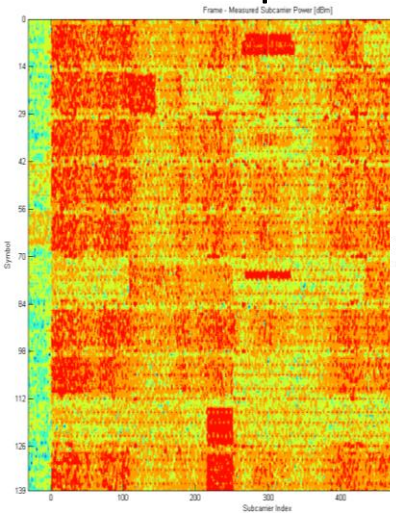
RF Channel Response



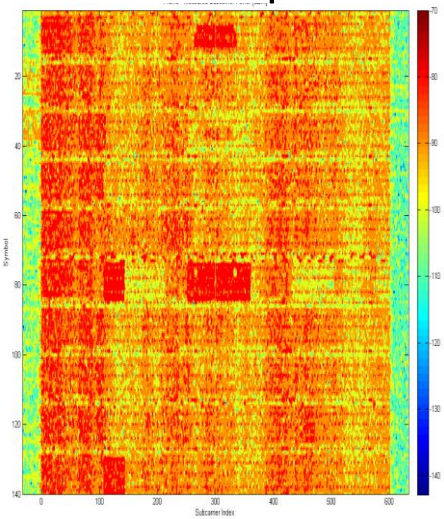
CellSpectrum

- Provides a unique antenna correlation analysis for MIMO estimation and adjustment

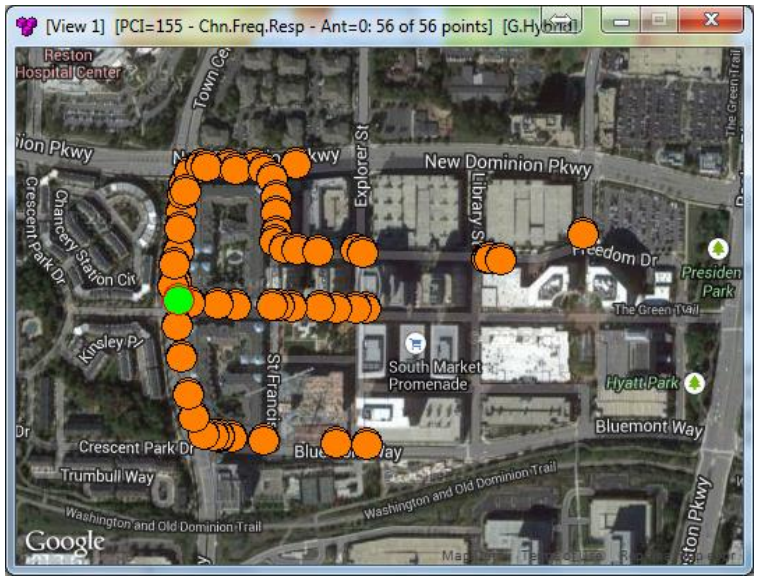
LTE frame port 0



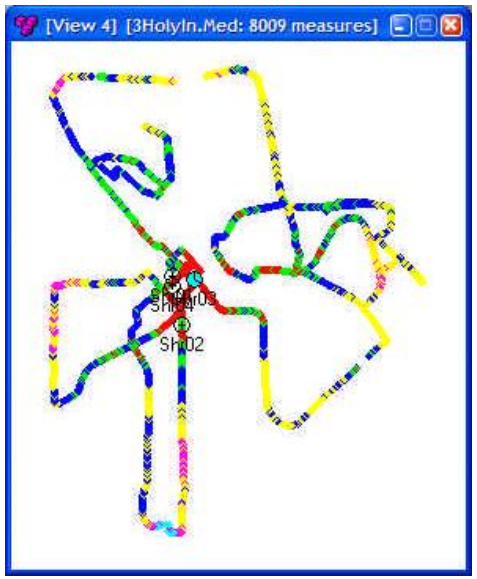
LTE frame port 1

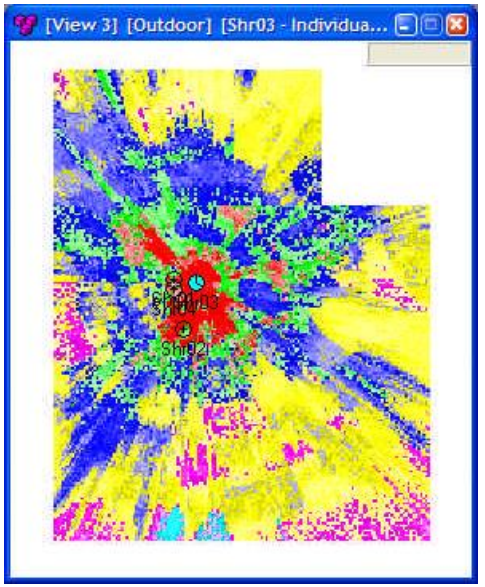


Drive Test



Measurement interpolation





CellDesigner

A new Generation of Planning Tools

A collaborative work with operators

Your input is valuable

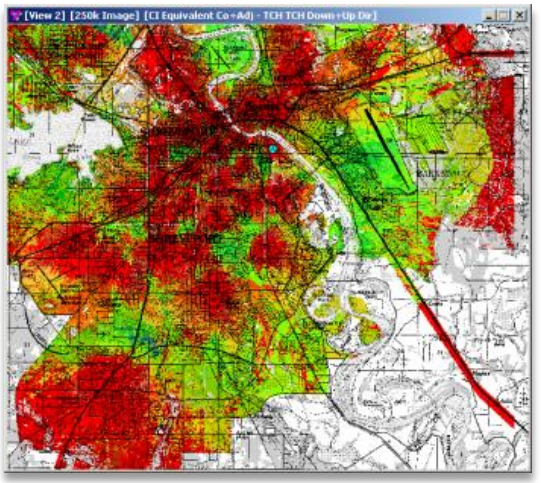
CellDesigner

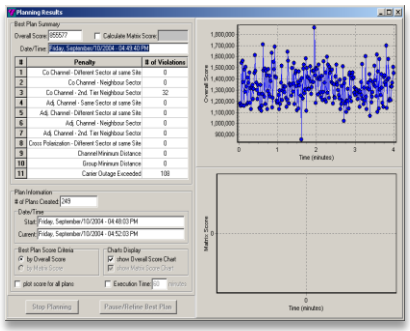
- CellDesigner is the new generation of Planning and Optimization tools
- Wireless networks became so complex that it requires a new generation of tools, capable of:
  - Documenting the physical deployments
  - Documenting network parameters for each technology
  - Flexible data traffic modelling (new services, new UE types)
  - Traffic allocation to different technologies
  - Fractional Resouce Planning
  - Performance evaluation
  - Integrated backhaul

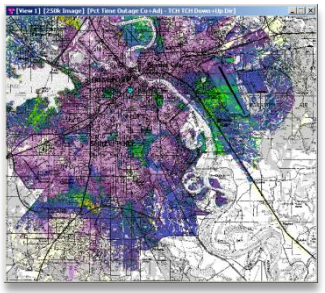
CellDesigner™

Simultaneous Multi-Technology Support

- Supports all wireless technology standards:
  - LTE–A (TDD and FDD), WiMAX, WI-FI, WCDMA (UMTS), HSPA, HSPA+, IS2000 (1xRTT, EVDO), GSM (including Frequency Hoping), GPRS, EDGE, EDGE-E, CDMA One, PMR/LMR (Tetra and P25), MMDS/LMDS, DVB-T/H, and Wireless Backhaul
- Full network representation
  - Site, Tower, Antenna Housing, Antenna System, Sector, Cell, Radio
  - Full network parameter integration
  - KPI integration
- Full implementation of the Korowajczuk 3D model, capable of performing simultaneously outdoor and indoor multi-floor predictions
- Multi-technology dynamic traffic simulation







CellDesigner™

Automatic Resource Planning (ARP)

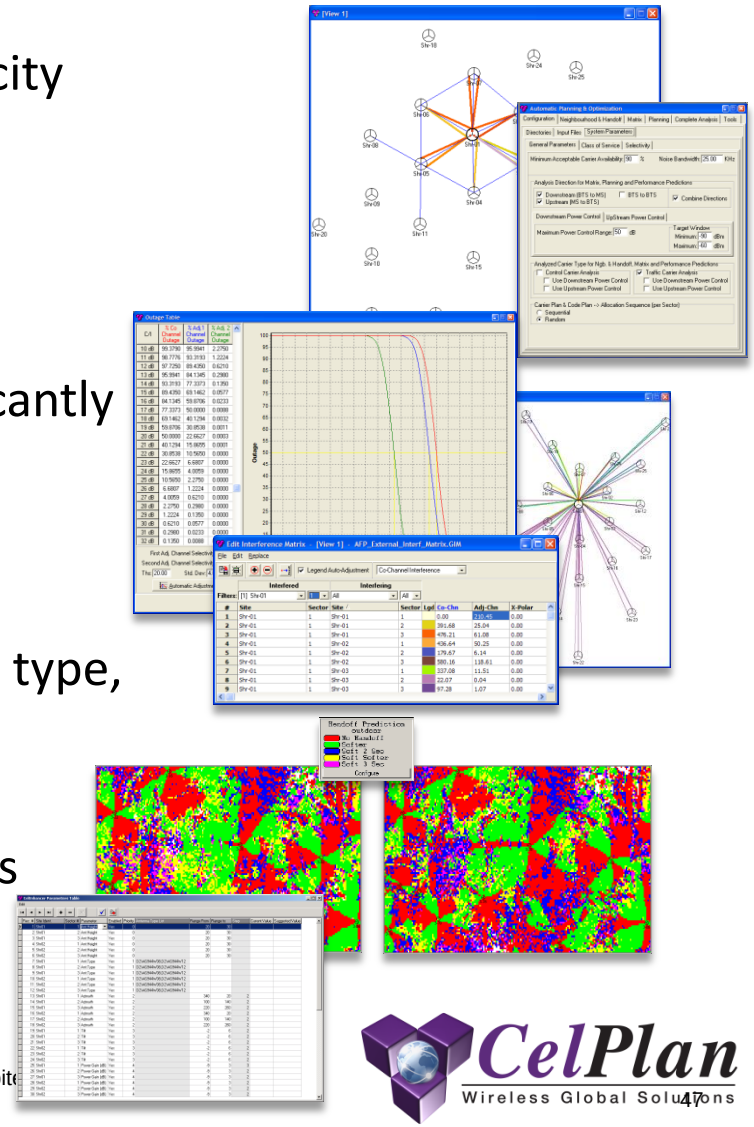
- Enables the dramatic increase of network capacity and performance
- Handover, Frequency and Code Optimization
- Automatically and efficiently optimizes handoff thresholds, neighbor lists, and frequency plans
- Patent-pending methodology capable of significantly increasing cell capacity (SON & ICIC)

Automatic Cell Planning (ACP)

- Footprint and interference enhancement
- Allows optimization of radiated power, antenna type, tilt, azimuth, and height

Performance Predictions

- Overall performance prediction per service class (bearer)



CellDesigner™

Google Earth Integration

- Capable of presenting predictions and measurements live in Google Earth's 3D environment

Network Master Plan (NMP)

- Patent-pending methodology that simplifies SON and ICIC

Integration of Field Measurement Data

- Collection of data from virtually any type of measurement equipment and any format
- Automatic extraction of propagation parameters

Integration of KPIs

- Comparison reports between reported and calculated KPIS

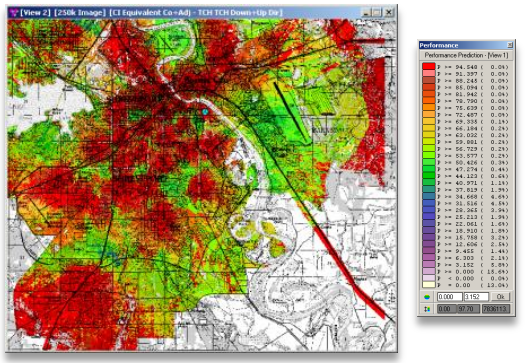
CellDesigner™

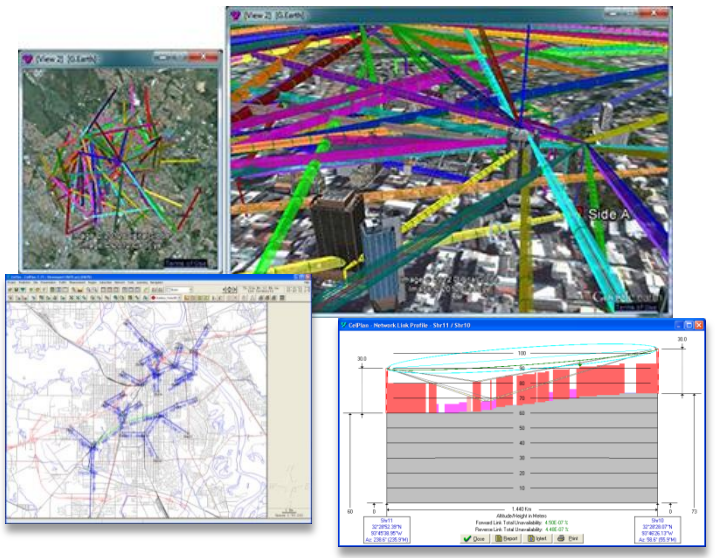
GIS Database Editor

- Allows the editing and processing of geographical databases

Backhaul Planning

- Calculates network interconnections, interference analysis & reporting for point-to-point, microwave transmission links
- Can display obstruction in Fresnel zones as well as the path loss
- Calculates attenuation caused by diffraction.
- Calculates rain attenuation for each link
- Provides link performance and compares against the requirements established by ITU-R





Thank You!

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Questions?