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HSPA/HSPA+ network planning and optimization

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Worth reading book with very good paper references!

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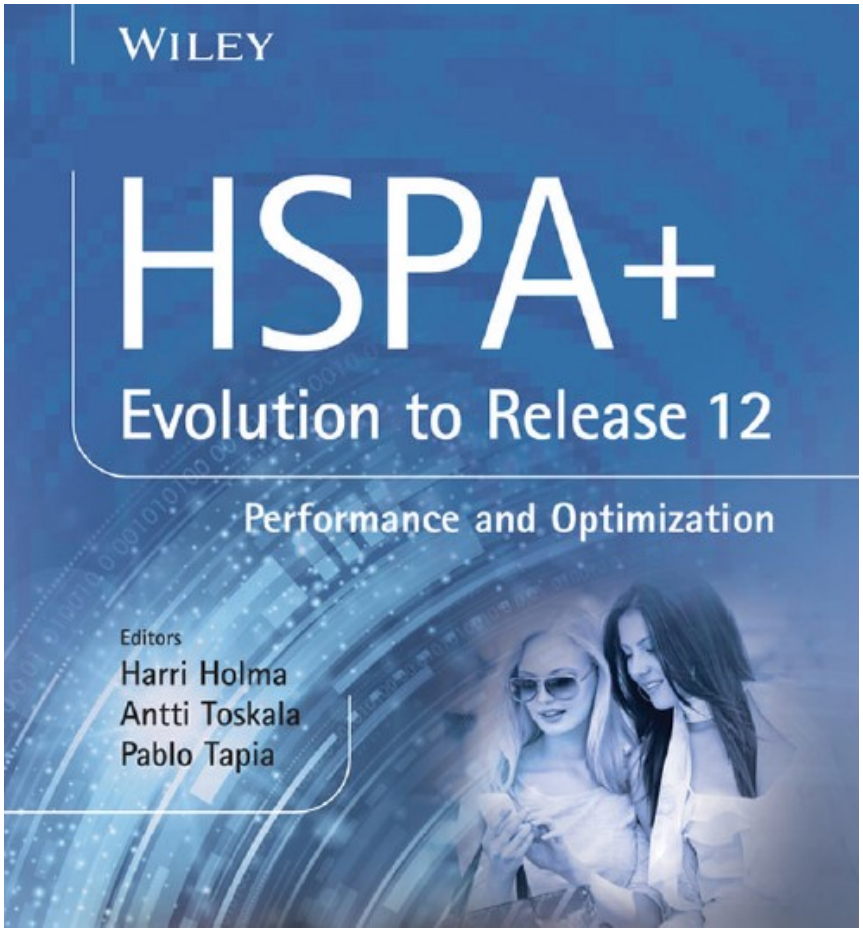

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- HSPA/HSPA+ requirements and targets
- HSPA/HSPA+ dimensioning
- HSPA/HSPA+ planning and optimization

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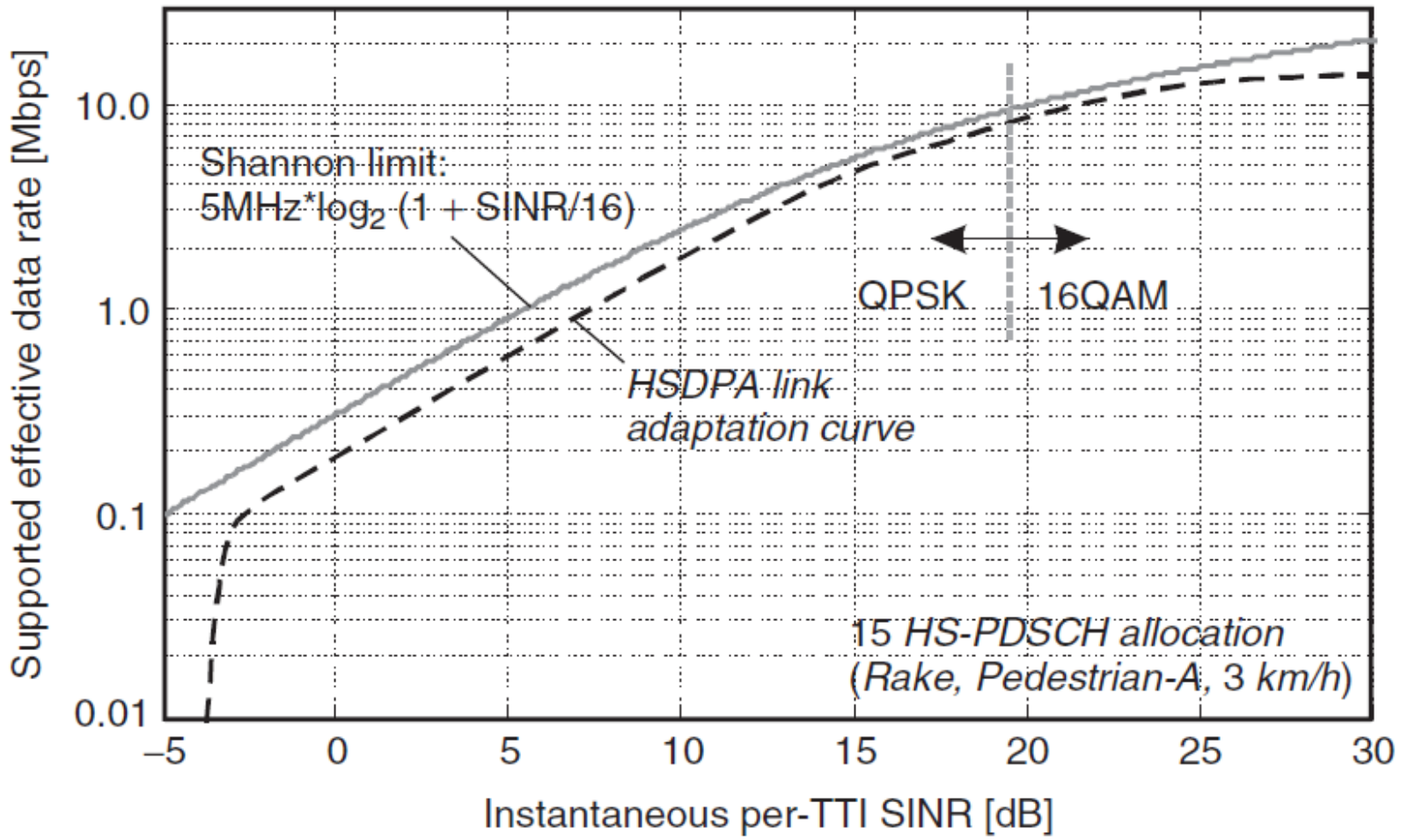
SINR to Throughput mapping for HSDPA



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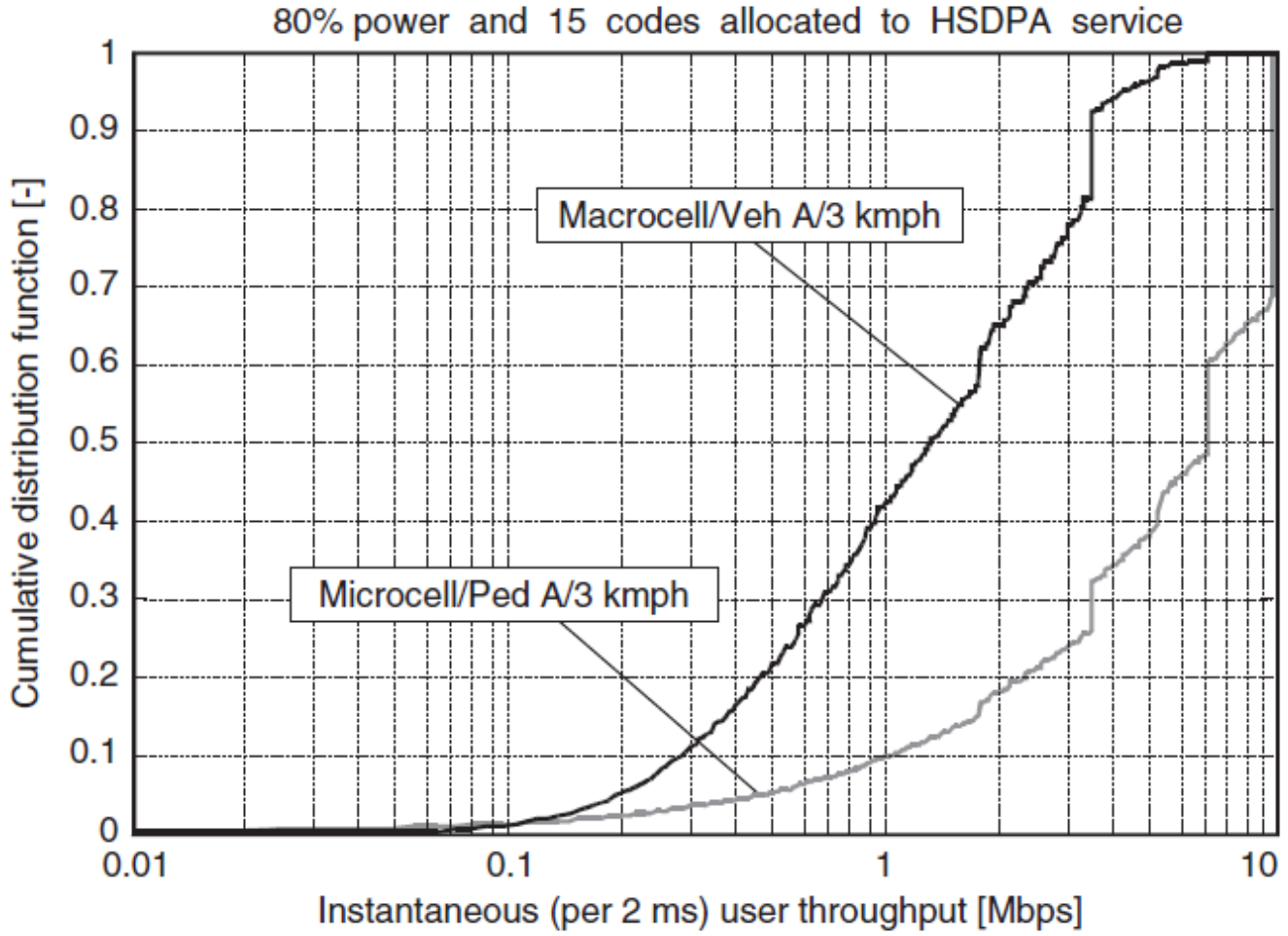
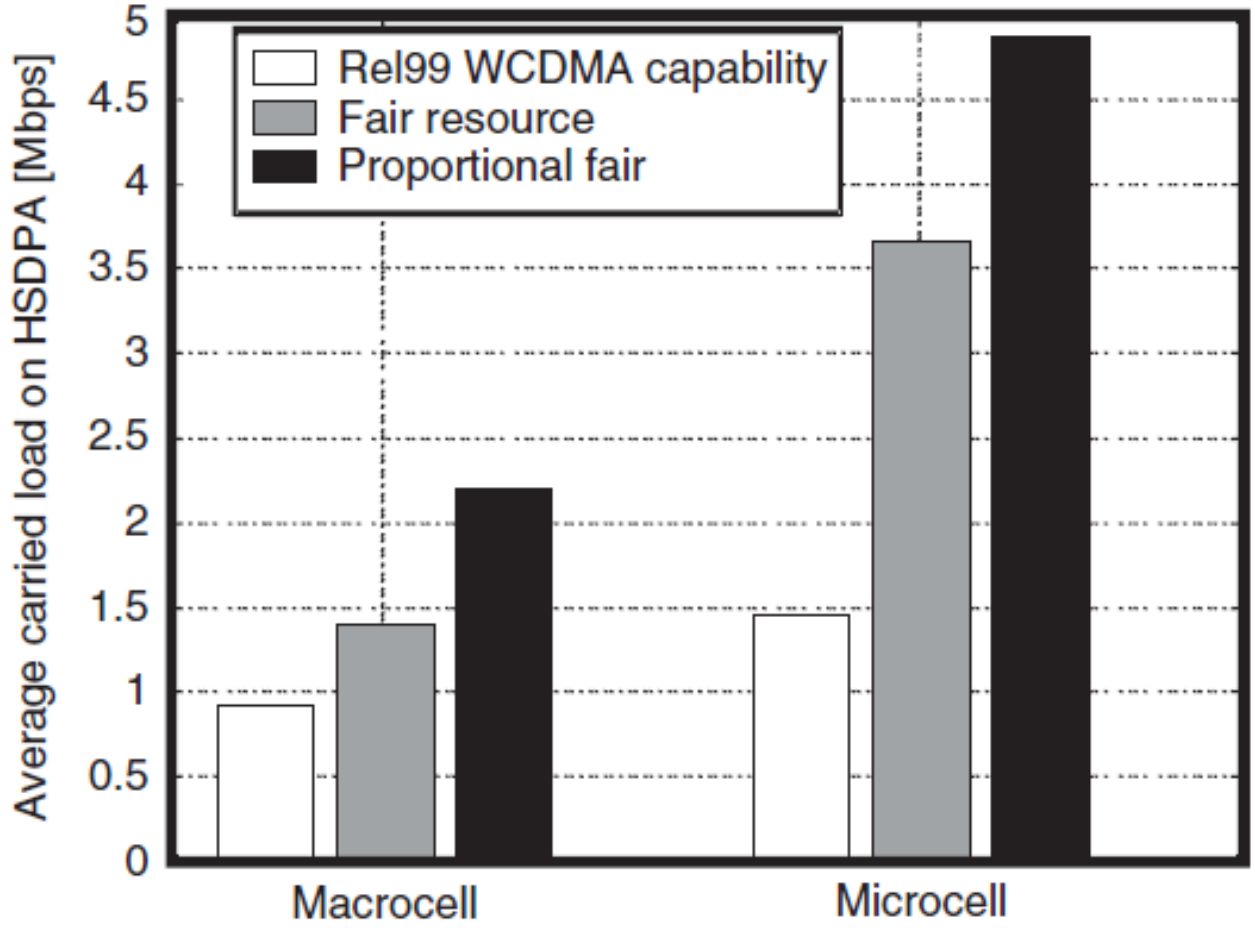
CDF of user throughput for HSDPA



WCDMA vs HSDPA



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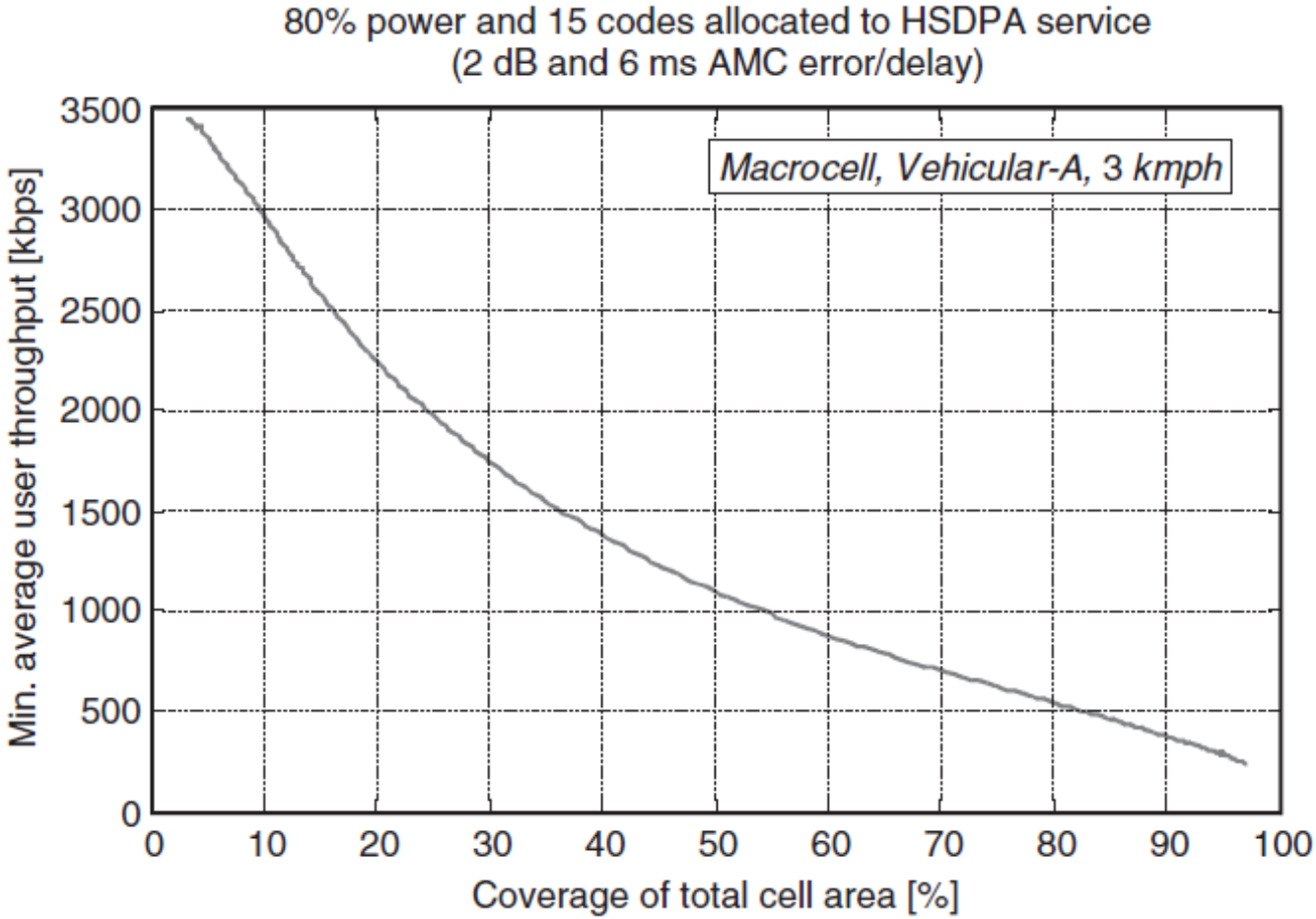
HSDPA coverage



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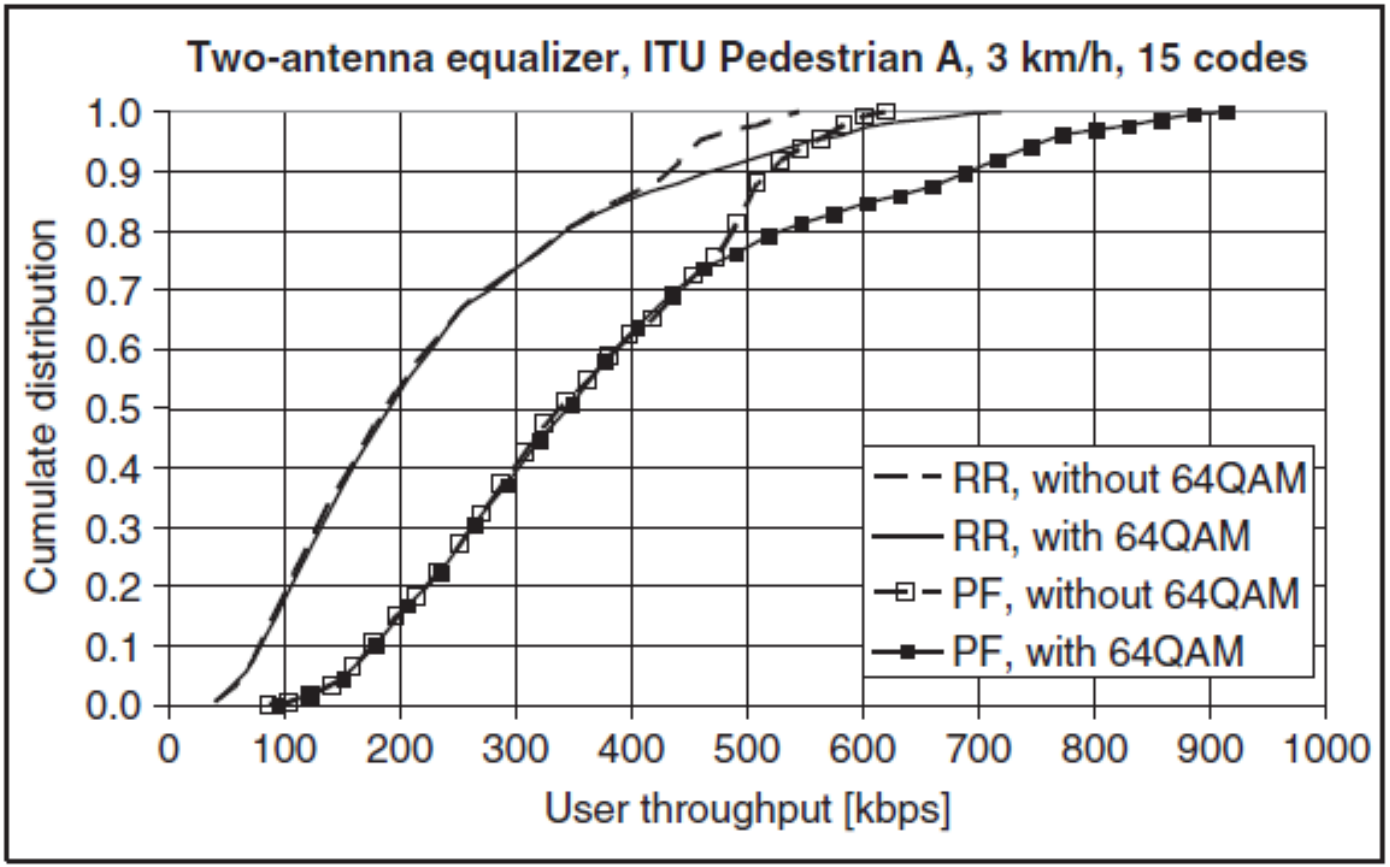
64QAM


Two-antenna equalizer, ITU Pedestrian A, 3 km/h, 15 codes
Cumulate distribution
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
100
200
300
400
500
600
700
800
900
1000
User throughput [kbps]
RR, without 64QAM
RR, with 64QAM
PF, without 64QAM
PF, with 64QAM

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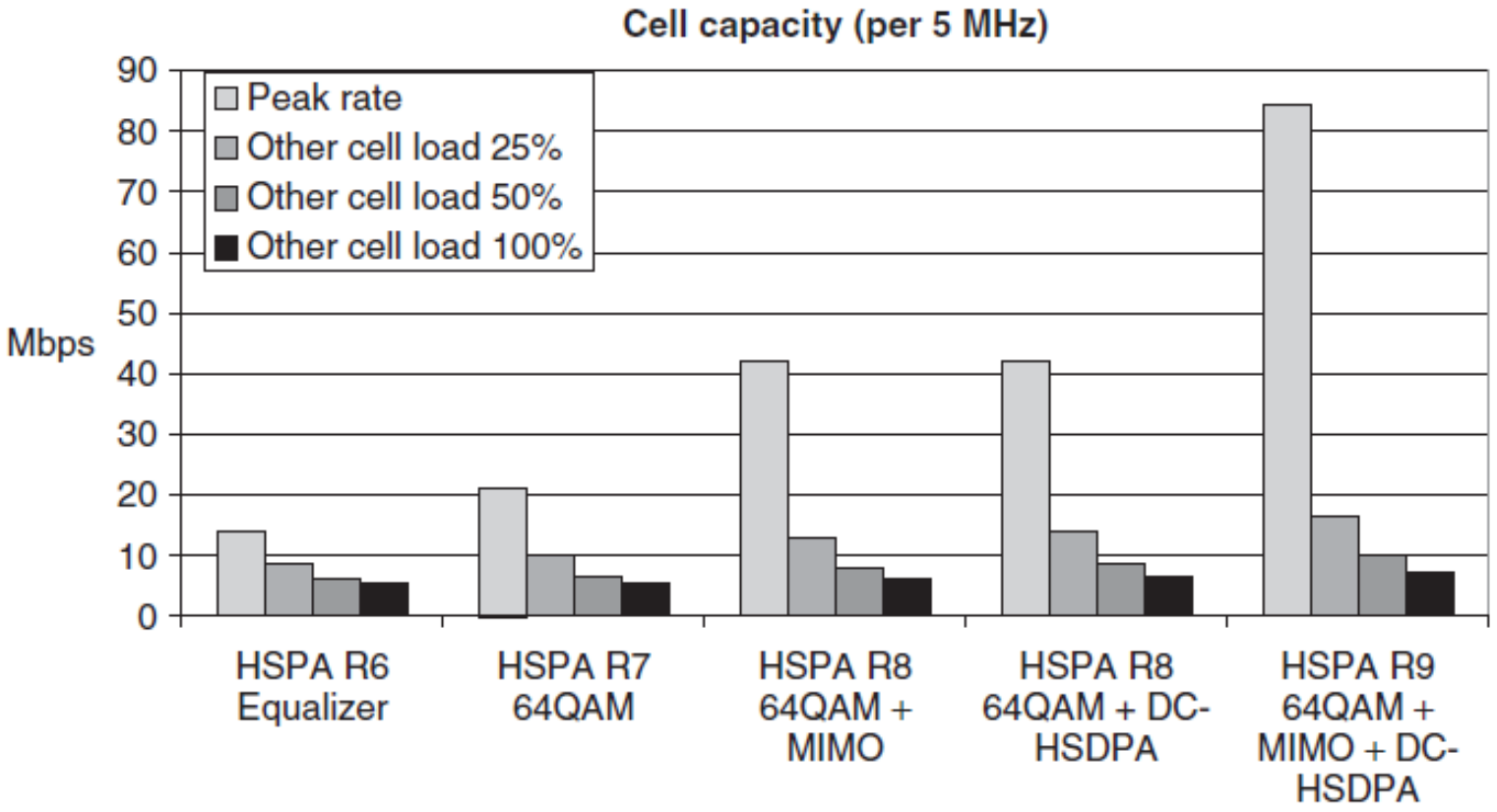
Peak rate and average cell capacity



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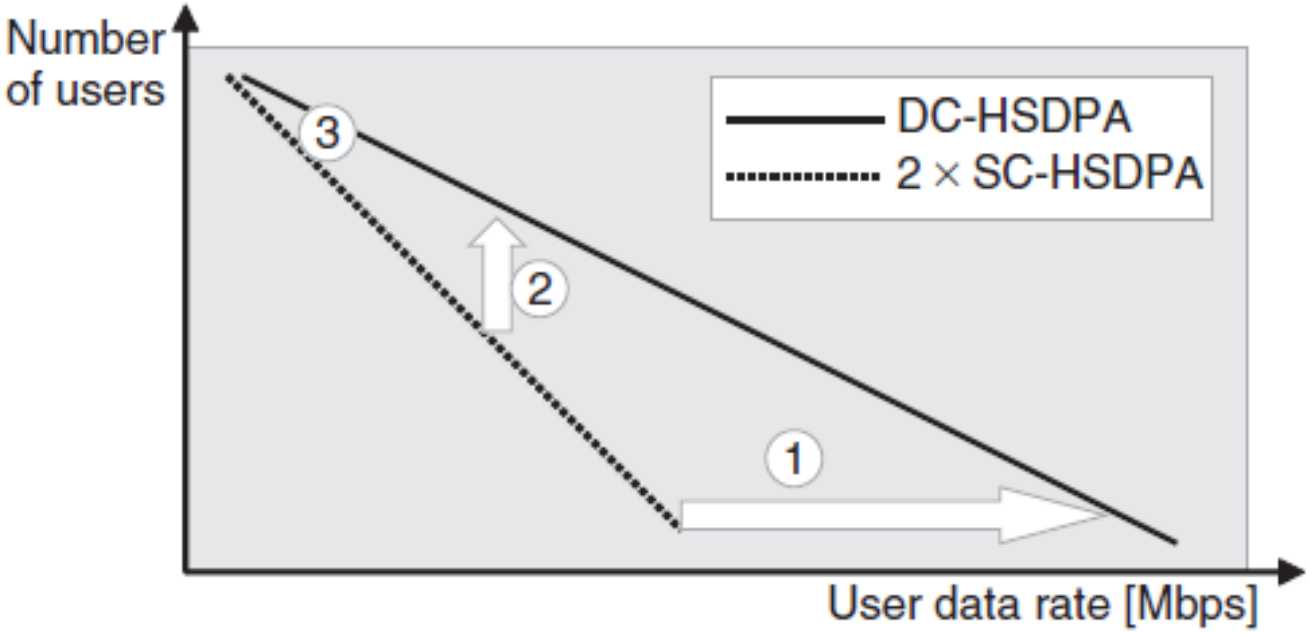
DC-HSDPA vs 2xSC-HSDPA



1 = Double data rate at low number of users

2 = Capacity gain with certain user data rate

3 = Slightly higher data rate at high number of users

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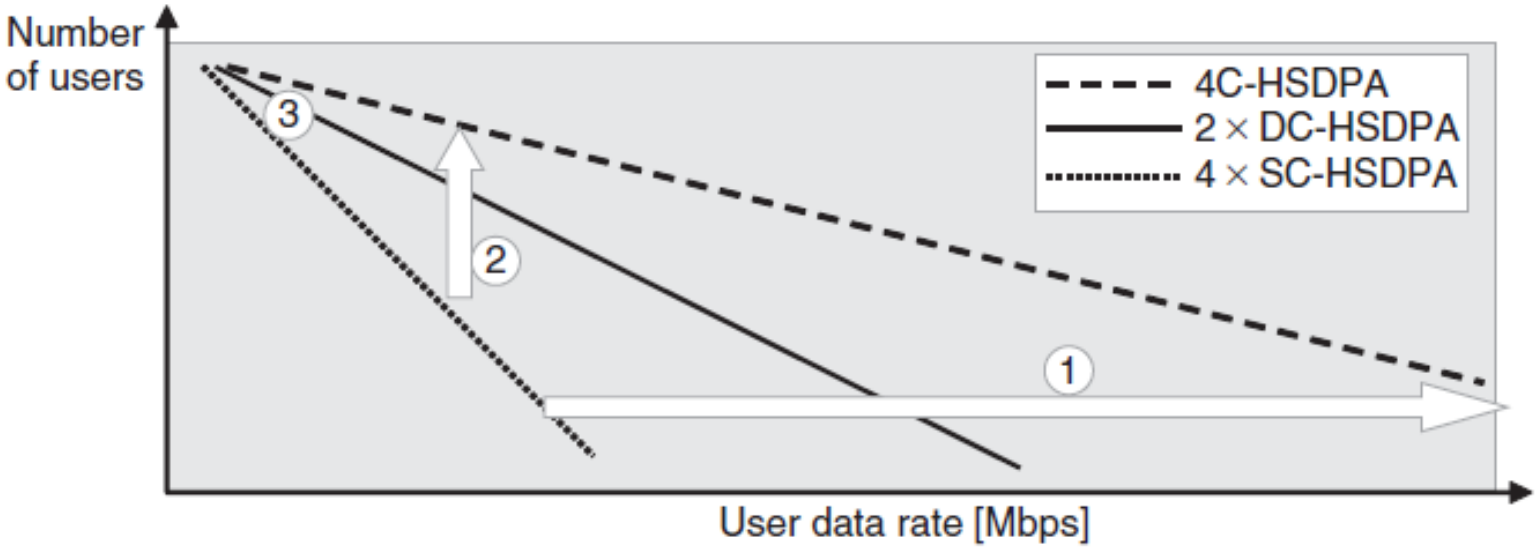
4C-HSDPA



1 = Four times higher data rate at low number of users

2 = Capacity gain with certain user data rate

3 = Slightly higher data rate at high number of users

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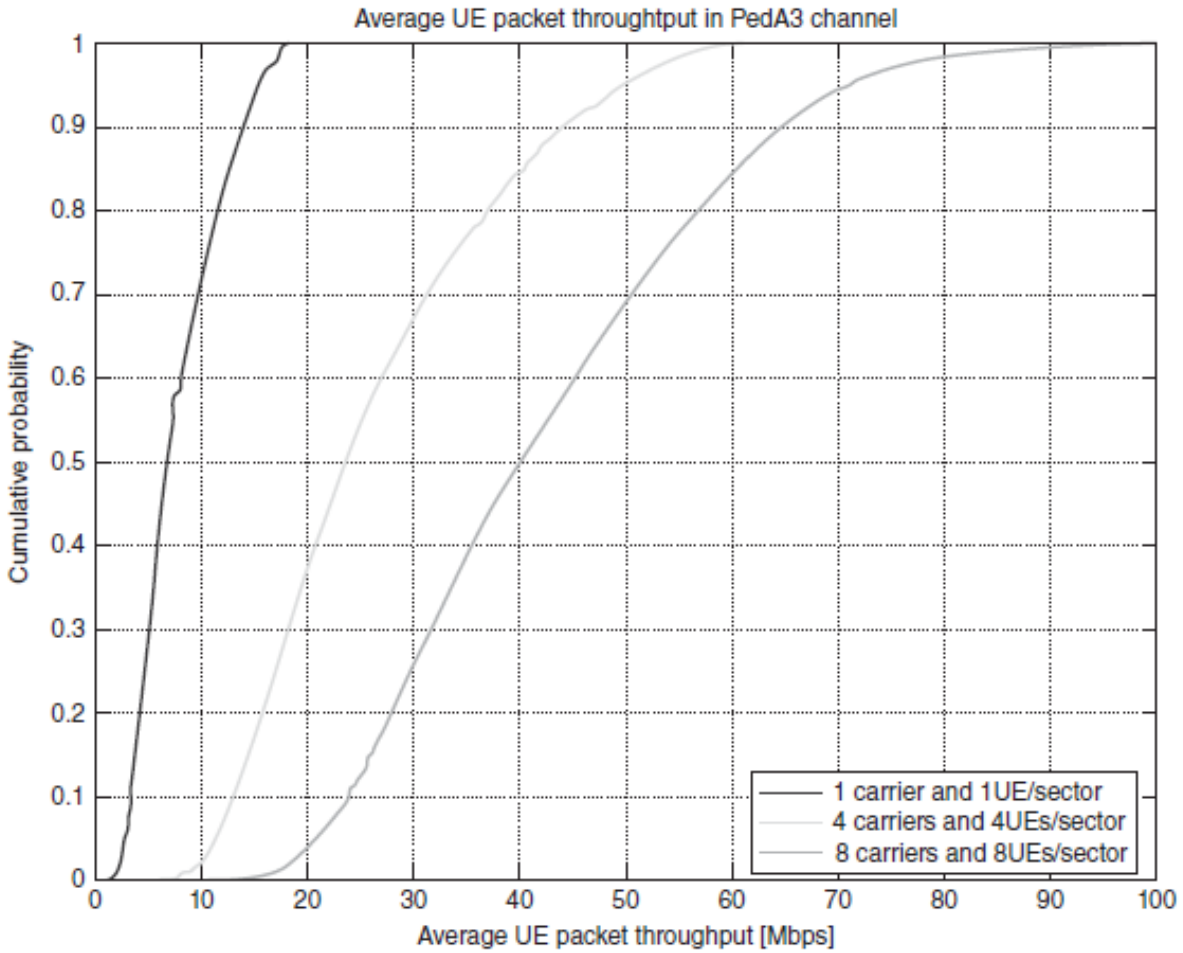
Cumulative distribution probability of the average device packet throughput for one, four, and eight carriers at low offered system load



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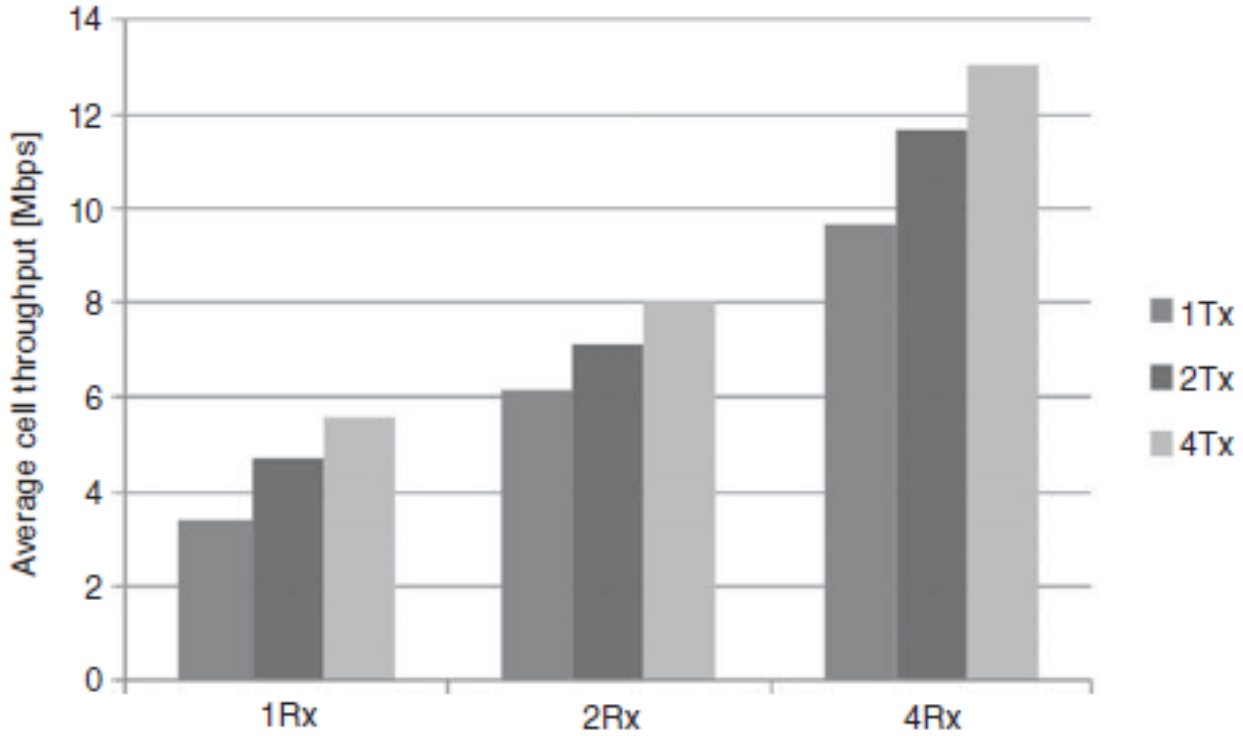
Average cell throughput with different numbers of Rx and Tx antennas



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Summery

		Peak rate	Average rate (capacity)	Cell edge rate	Latency gain	Talk time
Downlink	HSDPA 64QAM[1]	+50%	<10%	-	-	-
	HSDPA 2 × 2MIMO	+100%	<30%	<20%	-	-
	DC-HSDPA	+100%	+20-100%	+20-100%	-	-
Uplink	HSUPA 10 ms (2.0 Mbps)[2]	+600%	+20-100%	<100%	Gain 20 ms	-
	HSUPA 2 ms (5.8 Mbps)	+200%	<30%	-	Gain 15 ms	-
	HSUPA 16QAM	+100%	-	-	-	-
	Advanced Node B receiver	-	>30%	-	-	-
	DTX/DRX, Fast dormancy	-	-	-	-	> + 50%
	HS-FACH / HS-RACH	-	-	-	Setup time <0.1 s	-
	CS voice over HSPA	-	+80% (voice)	-	-	> + 50%

[1]Baseline WCDMA Release 5 downlink 14.4 Mbps

[2]Baseline WCDMA Release 99 uplink 384 kbps

= clear gain >30%

= moderate gain <30%

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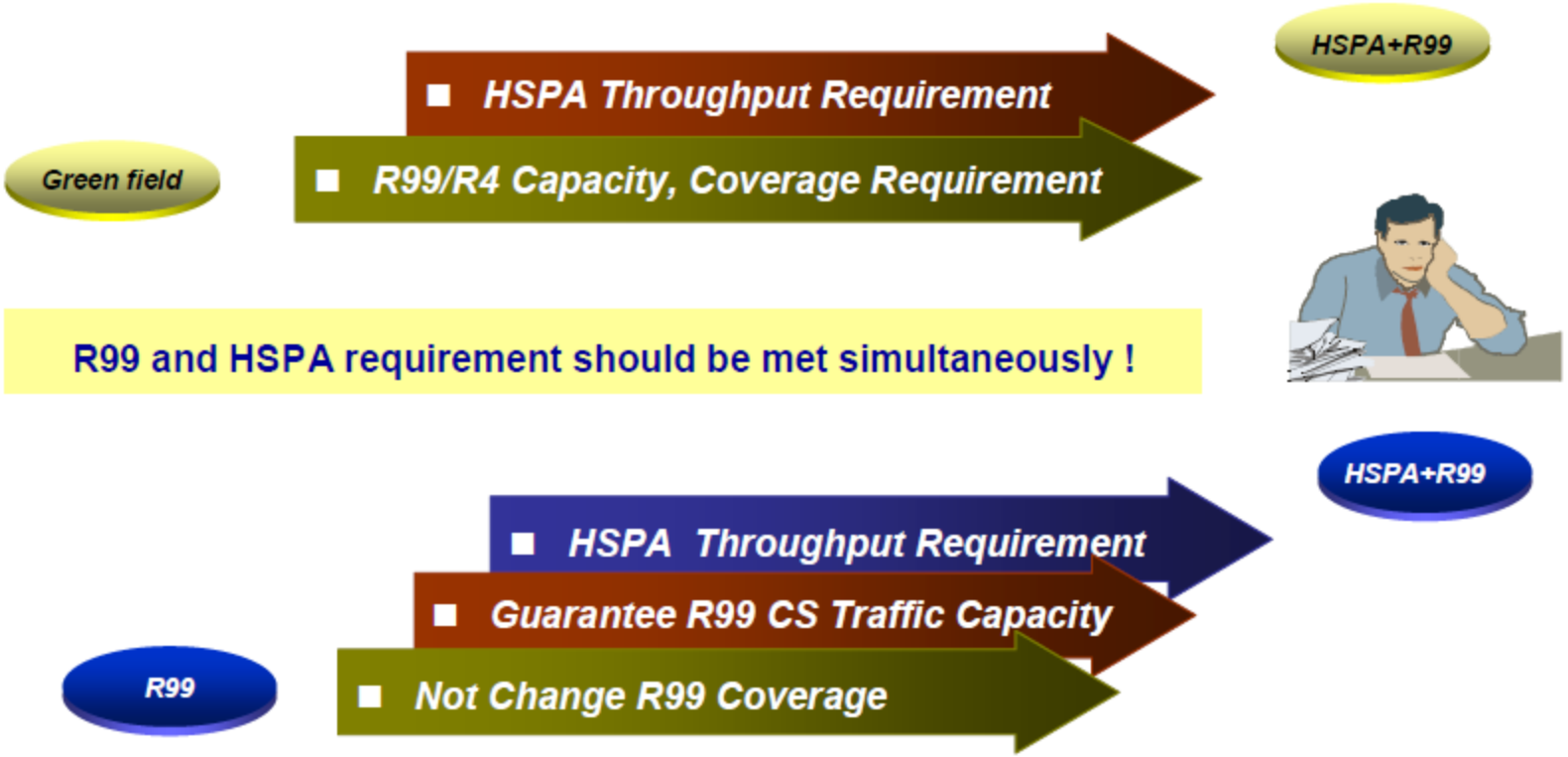
WCDMA vs HSPA requirments



Capacity requirements/targets

- Defined based on at least:
  - Forecasted/required number of **HSPA/HSPA+ subscribers/users**
  - Forecasted/required **traffic demand matrix** based on data services
- Important to articulate capacity in spatial and temporal domain
- Both cell capacity and network capacity demand need to be set.

Think on:

How much is *satisfactory average per user data rate demand(s)* for Ethiopian HSPA/HSPA+ users?
How do you explain the *spatial distribution* of the HSPA/HSPA+ users and their data rate demand?
How do you explain the *temporal distribution* of the HSPA/HSPA+ users and their data rate demand?

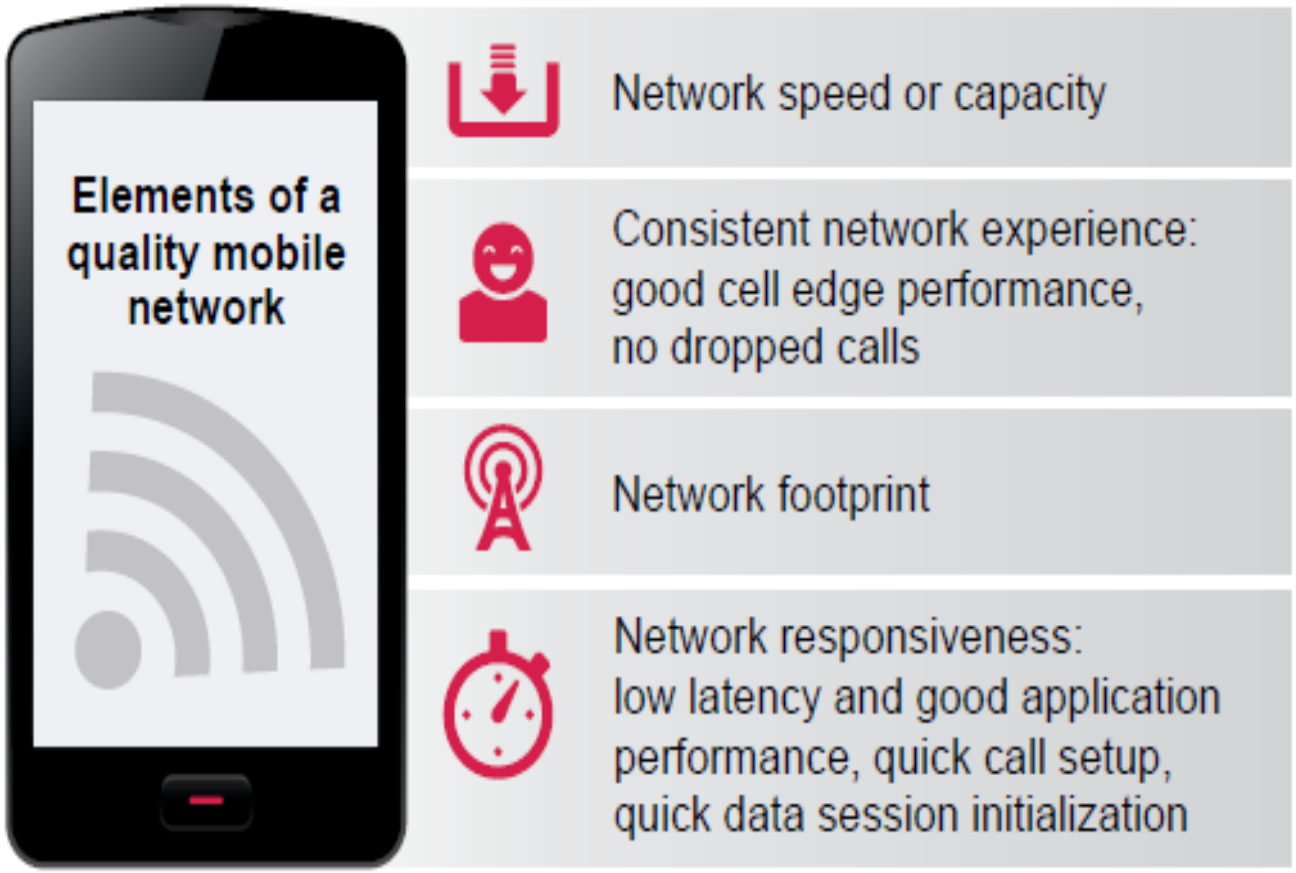
Coverage requirements/targets

- What is very important in data service coverage is coverage of a given minimum required data rate for the service
- In a given location and time:
  - If the minimum required data rate is achieved we are under service
  - If the minimum required data rate is not achieved we are in outage

Think on:

For HSPA/HSPA+ service, with what minimum data rate we say we are under HSPA/HSPA+ coverage?

QoS requirements/targets



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Other requirements/targets

- Available carriers/bandwidths
- Already decided product specifications
  - Base stations
  - Antennas
- UE categories and capabilities
  - UE adoption trend
- Site locations
- Financial limitations
- Future plans
- Deployment strategy

Note planning targets should be agreed being defined well in prioritized manner.

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Deployment strategy

Professional Deployment strategies will be provided according to your requirement, *which will focus on the ROI(RETURN ON INVESTMENT).*

- CAPEX
  - Initial Investment
  - Deployment investment
- OPEX
  - Optimization service
  - Consultant service

- User Experience
- Market Demand
- Available New Feature
- New Application Service
- New HSPA UE/HSPA UE Penetration
- Competition from other operator

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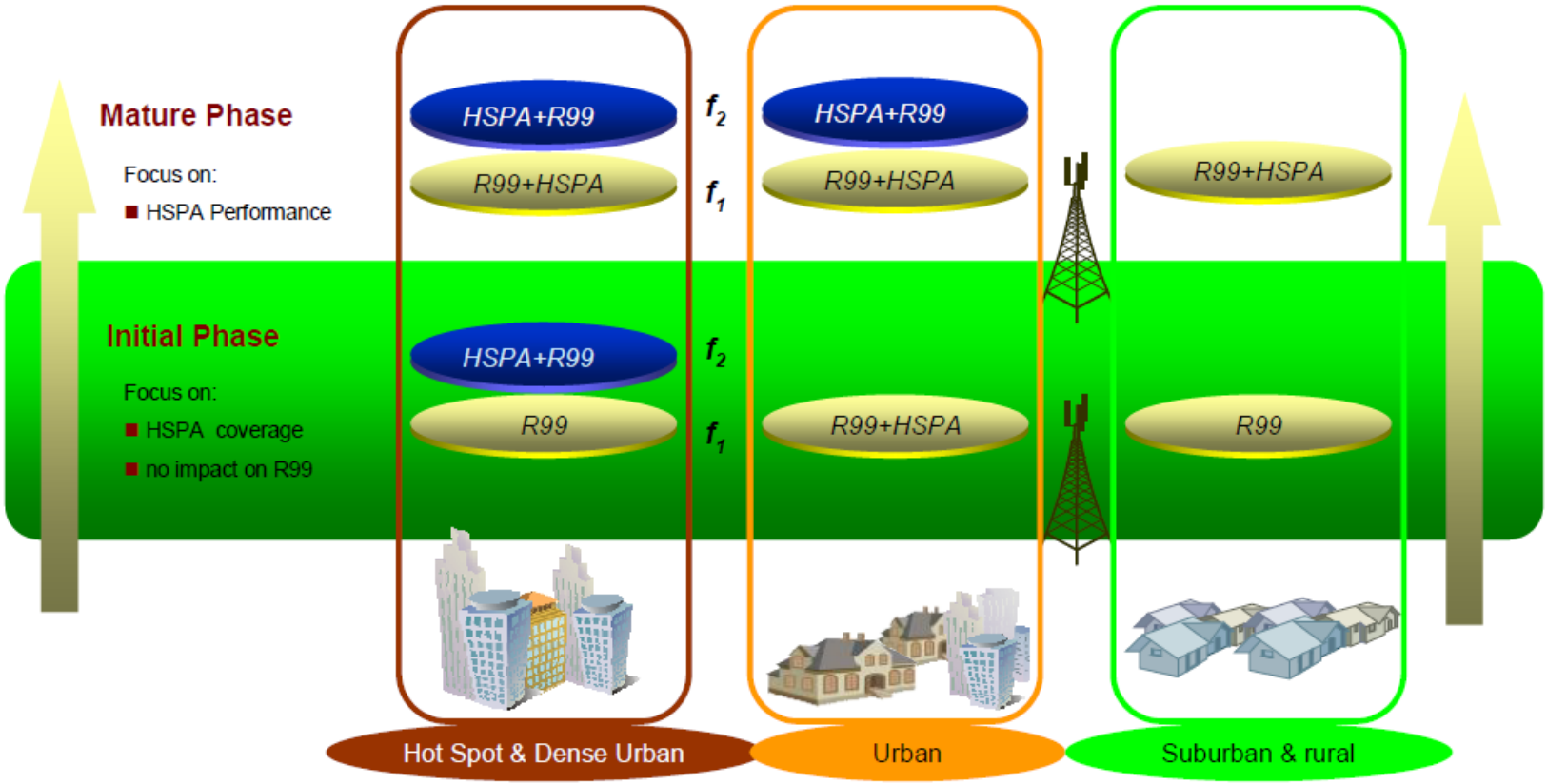
Deployment strategy



Operator's data strategy?

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Coverage dimensioning

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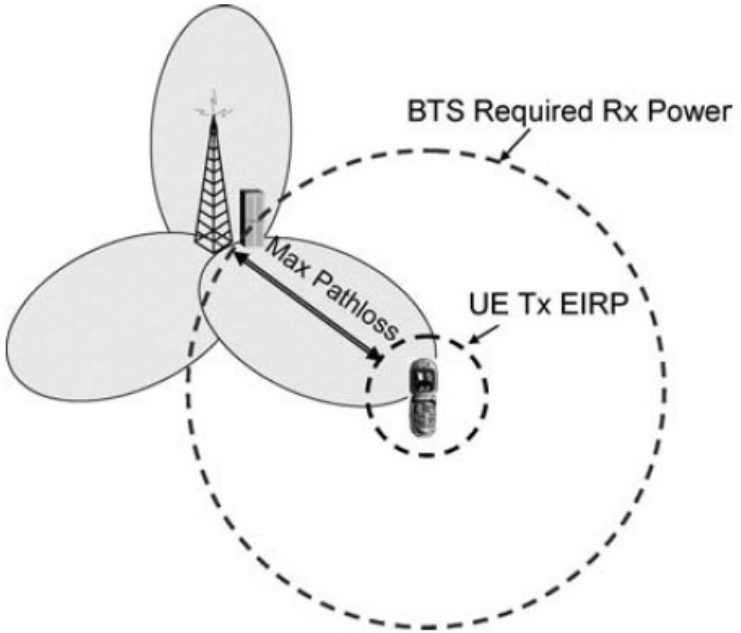
Why link budget?

- Allows planner to have high level estimates of the cell ranges for different data services.
  - Allows planner to create a comparison of the coverage footprints between HSPA and the underlay network.
- Based on assumptions provided by product specifications, the 3GPP standards or simulation results.
  - Some parameter values need to be verified with drive test field measurements collected during the early stages of deployment or from trial networks.



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HSDPA link budget, 512 kbps (see WCDMA 384kbps)

		HS-DSCH 512kbps		HS-SCCH	
Transmitter characteristics	Total BS transmitter power	20	W		
	Total BS transmitter power	43.0103			
	Transmitter power on HS_DSCH	16	W	1	W
		42.0411998	dBm	30	dBm
	TX antenna gain	17.4	dBi	17.4	dBi
	TX cable loss	2	dB	2	dB
	Transmitter EIRP	**57.4411998**	**dBm**	**45.4**	**dBm**
Receiver characteristics					
	Thermal noise density	-173.97518	dBm/Hz	-173.975	dBm/Hz
	Receiver noise figure	8	dB	8	dB
	Receiver noise density	-165.97518	dB	-165.975	dB
	Receiver noise power	-100.13187	dBm	-100.132	dBm
	Spreading gain	12.0411998	dB	21.0721	dB
	SINR	6	dB	1.5	dB
	Receiver sensitivity	-106.17307	dB	-119.704	dB
	Load factor	0.75		0.75	
	Interference margin	6.02059991	dB	6.0206	dB
	RX antenna gain	0	dBi	0	dBi
	RX Body loss	0	dB	0	dB
	Diversity gain	0	dB	0	dB
	Fast fading margin	0	dB	0	dB
	Soft handover gain	0	dB	0	dB
	Indoor penetration loss	0	dB	0	dB
	Coverage probability (cell edge)	0.9		0.9	
	Shadow fading std deviation	6	dB	6	dB
	Shadow Fading Margin	7.5	dB	7.5	dB
	Allowed propagation loss	**150.093671**	**dB**	**151.5834**	**dB**

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HSDPA link budget, 512 kbps

- 80% of the carrier power on HS-DSCH
- 5% of the carrier power on HS-SCCH
- Parameters selected similarly with WCDMA 384kbps link budget
- Differences to WCDMA:
  - Spreading gains are fixed in HS-DSCH (=16) and in HS-SCCH (=128)
  - SINR value is defined by link simulations (like Eb/No in WCDMA)
  - Fast fading margin is not needed, link adaptation is applied.
  - No soft handover on HS-DSCH => no SHO gain
- Comparison:
  - WCDMA 384kbps: allowed path loss = 143.6dB
  - HSDPA 512kbps: allowed path loss = 150.1dB

SINR computation

$$SINR = SF_{16} \times \frac{p_{\text{HSDPA}}}{(1-\alpha)P_{\text{own}} + P_{\text{other}} + P_{\text{noise}}} = SF_{16} \times \frac{p_{\text{HSDPA}}}{P_{\text{TOT\_BS}}\left(1-\alpha+\frac{1}{G}\right)}$$

HSDPA throughput vs. SINR (for 10% BLER)

SINR	Throughput with 5 codes	Throughput with 10 codes	Throughput with 15 codes
0	0.2	0.2	0.2
5	0.5	0.5	0.5
10	1	1.2	1.2
15	1.8	2.8	3
20	2.8	4.2	5.5
25	3.1	5.8	7.8
30	3.3	6.7	9.2

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Key differences in HSUPA link budget relative to WCDMA uplink

- Two key differences:
  1) Existence of a power reduction factor or back-off with HSUPA
     - ✓ Due to high PAPR resulting from using parallel multiple codes
  2) The increased overall interference level when a high-bitrate HSUPA user is admitted in the cell.
- ➢ If these factors are not considered, the link budget will provide optimistic results.

$$\text{NRAdjustment Factor } (K) = 10 \cdot \log_{10}\left(1 + v \cdot \left(\frac{Eb}{Nt}\right) \cdot \left(\frac{R}{W}\right)\right)$$

Eb/No vs. Throughput for a Category 5 HSUPA device (10 ms TTI, 1.92 Mbps Max Bitrate)

Throughput (kbps)	Transport block size (bits)	Ec/Nt (dB) of 1st transmission	Required Eb/Nt (dB)	Commercial PA back-off (dB)
61	1026	−13.9	1.6	2.4
121	2052	−11.1	1.1	2.1
216	4068	−8.7	1.0	1.9
526	10152	−4.6	1.1	1.1
717	14202	−2.9	1.4	0.9
808	16164	−2.1	1.7	0.8

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Example HSUPA link budget (Pablo book)

Table 5.8 Example link budget calculations for different uplink bitrates

	Parameters & Calculations	Target UL Data rates (kbps)		
		1000	500	64
UE Tx Power	UE Maximum Transmit Power (dBm)	21.0	21.0	21.0
	UE cable & other losses (dB)	0.0	0.0	0.0
	UE Transmit Antenna gain (dBi)	0.0	0.0	0.0
	Power back off factor (dB)	0.6	1.1	2.3
	Mobile EIRP(dBm)	20.4	19.9	18.7
Required Power at the BTS	Thermal noise density (dBm/Hz)	−174.0	−174.0	−174.0
	BTS Receiver Noise Figure(dB)	3.0	3.0	3.0
	Thermal noise Floor(dBm)	−105.2	−105.2	−105.2
	UL Target Loading (%)	0.6	0.6	0.6
	UL Noise Rise (dB)	4.0	4.0	4.0
	Required Eb/Nt (dB)	2.0	1.1	1.5
	Processing Gain (dB)	5.9	8.9	17.8
	Interference Adjustment Factor (dB)	2.5	1.2	0.2
	Node B Rx Sensitivity (dBm)	−99.8	−104.9	−113.9
Maximum Pathloss	BTS antenna gain (dBi)	18.0	18.0	18.0
	BTS Cable connector combiner losses (dB)	4.0	4.0	4.0
	Slow Fading margin (dB)	−9.0	−9.0	−9.0
	Handover gain (dB)	3.7	3.7	3.7
	BTS Body Loss (dB)	0.0	0.0	0.0
	Maximum Allowable Pathloss (dB)	*132.7*	*136.9*	*144.7*

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Capacity dimensioning

Made based on results of **product survey** and **capacity demand matrix**.

More important if network is capacity limited!

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Key points to note in HSPA planning compared to WCDMA planning

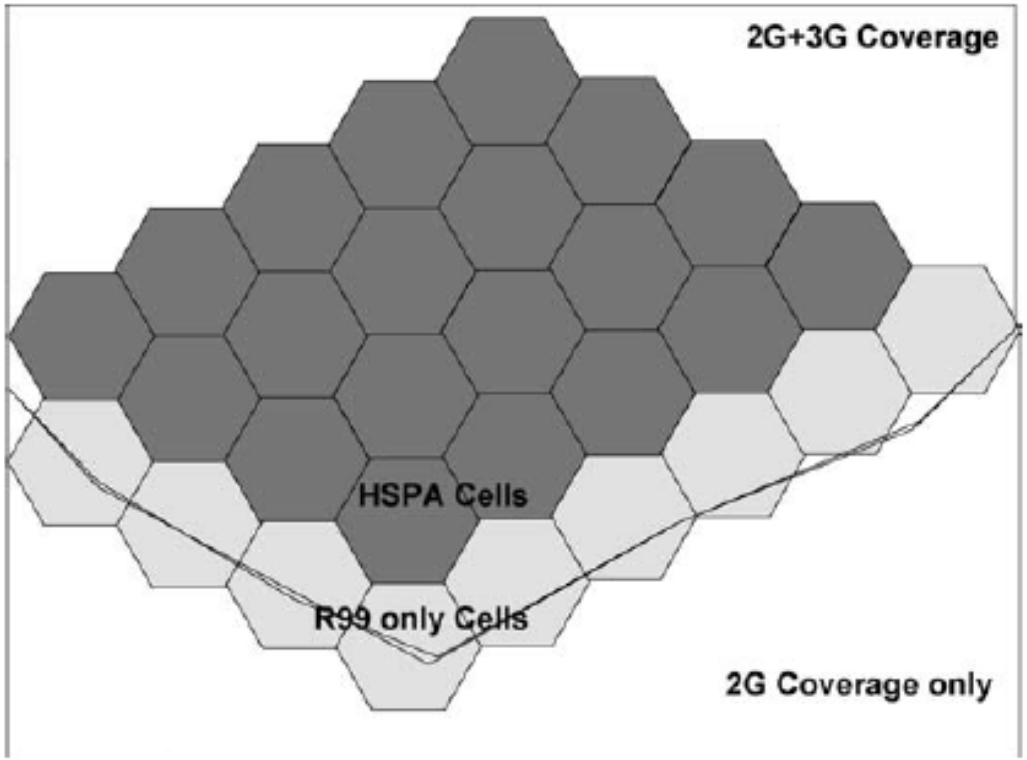
- Data typically is highly asymmetrical with more traffic on the downlink compared to the uplink
  - Performance, planning and optimization of HSDPA will usually take precedence over HSUPA
- Bursty nature of data traffic together with the availability of higher data rates results in higher instantaneous transmit powers, which can raise the interference levels over short time periods.
  - This can cause quality degradations to existing Rel.'99 voice users in the cell
  - Careful planning is required to balance voice and data performance and manage the associated tradeoffs.

Key points to note in HSPA planning compared to WCDMA planning

- HSDPA and HSUPA use lower spreading factors compared to their Rel.'99 predecessors
  - Lower spread spectrum processing gain
  - Compensated by the increased amount of transmit power allocated to the user, HARQ
  - Typically, HSDPA can operate at BLER target levels of 15% or even 20% as compared to 10% for Rel.'99 channels
- Ec/No vs CQI
  - Careful interpretation of Ec/No when we have HSPA
- More HSPA Baseband and Backhaul Resource Considerations

Key points to note in HSPA planning compared to WCDMA planning

- Most HSPA networks do not support direct transition to (E)GPRS



Rules of thump for HSPA planning

1. Pilot power: assign it considering the coverage-capacity tradeoffs as it affects cell coverage

- E.g. In dense traffic area less power and in rural area high power

2. Cell size: limit cell size only to coverage target as it affects neighboring cell interference level, thus coverage/capacity

3. Site location: cell sites are placed near to where the bulk of the users are located to achieve higher overall network capacity

- As soft capacity of a HSPA cell is highly dependent on where the traffic comes from

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Rules of thump for HSPA planning

4. Capacity Enhancing Mechanism: Sites might be designed primarily based on **coverage** and **service quality** for a certain traffic load, and additional capacity should be provided through additional carriers

- offloading the traffic from the overload sites adding sites vs controlling the interference of the new cell

5. Soft-Handover Planning: HSDPAshould aim at a soft-handover area below 40% (20% would be a good target for data only networks)

6. HSDPA Additional Interference: effect of the increased interference level should be accounted for in the neighboring sites as HSDPA cells can increase power levels close to 100%

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Rules of thump for HSPA planning

7. In-building Coverage Planning: Not a good idea to cover buildings with signals coming outdoor as the excessive power needed to cover in-building users create harmful interference to the outdoor users

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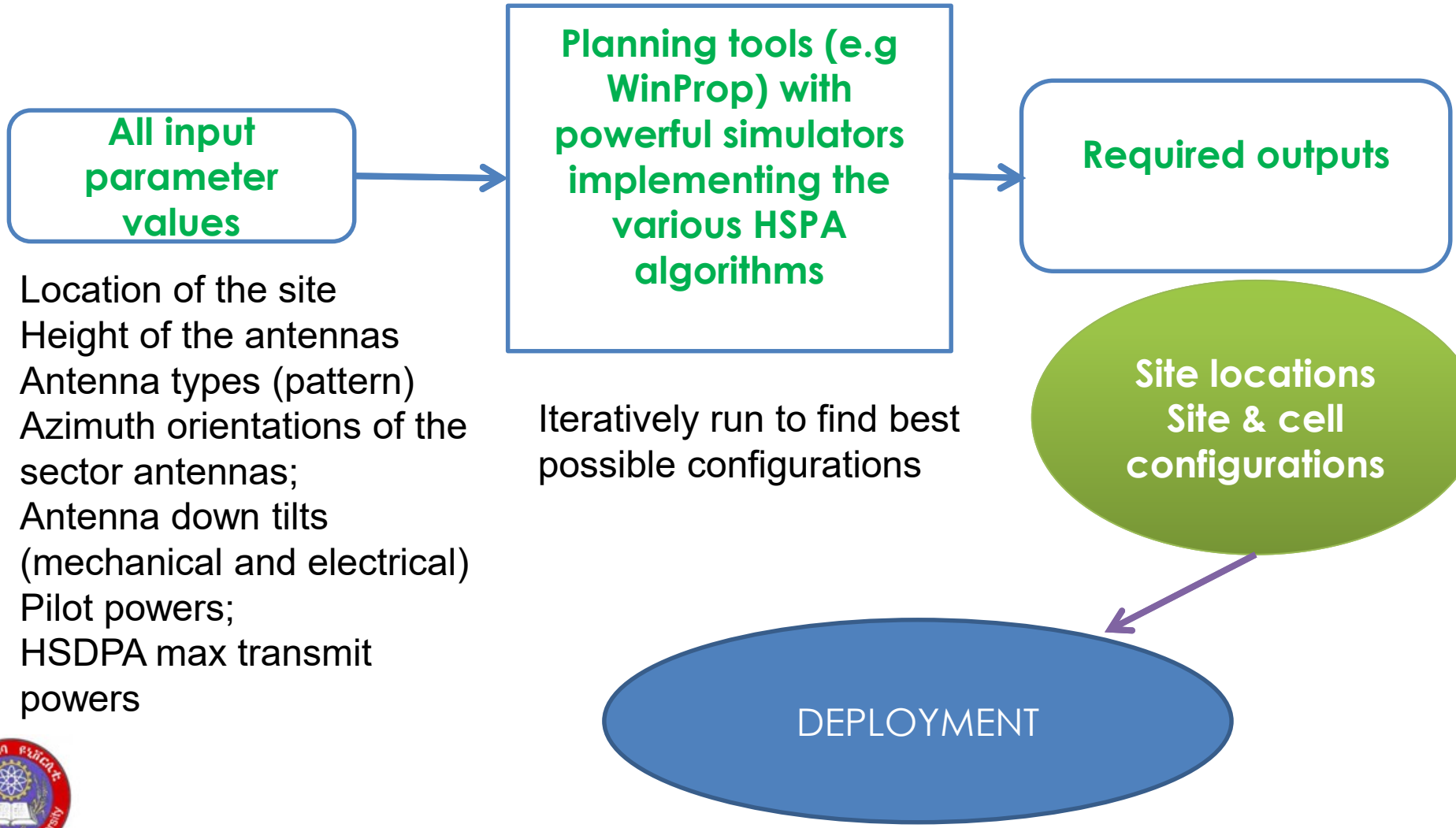
Rules of thump for HSPA+ planning

Understand well the planning impact, how to use and when to use of the additional features (Multicarrier, MIMO, High order modulation and their combination) and use them accordingly.

HSPA radio planning process

Objective: to find the best site locations and configurations that achieve network coverage, capacity and quality targets with the minimized deployment costs



Optimization based on OSS and drive test data

Drive test: radio parameters

- Initial drive tests will be focused on the basic radio parameters to ensure that the coverage of the area matches the predictions from the planning tool

Some parameters to be measured with drive test:

CPICH Received Signal Code Power (RSCP): pilot RSCP should not be less than a threshold target, for example -110 dBm

Unloaded pilot channel Ec/No measured in idle mode: identifies the presence of 'pilot pollution'

- Healthy levels of Ec/No for good RSCP received powers (above -95 dBm) in unloaded conditions should be on the order of -4 to -7 dB.

Average number of cells in the active set: indicates the cell overlap between neighboring cells

Strength of RSCPs in the neighboring cells: helps to refine the neighbor lists and identify missing neighbors

Call setup success rate: assesses the overall Rel.'99 call quality for mixed voice and data networks

CQI distribution for a single user drive: indicates the radio conditions perceived by the HSDPA device, enable to estimate the achievable throughputs

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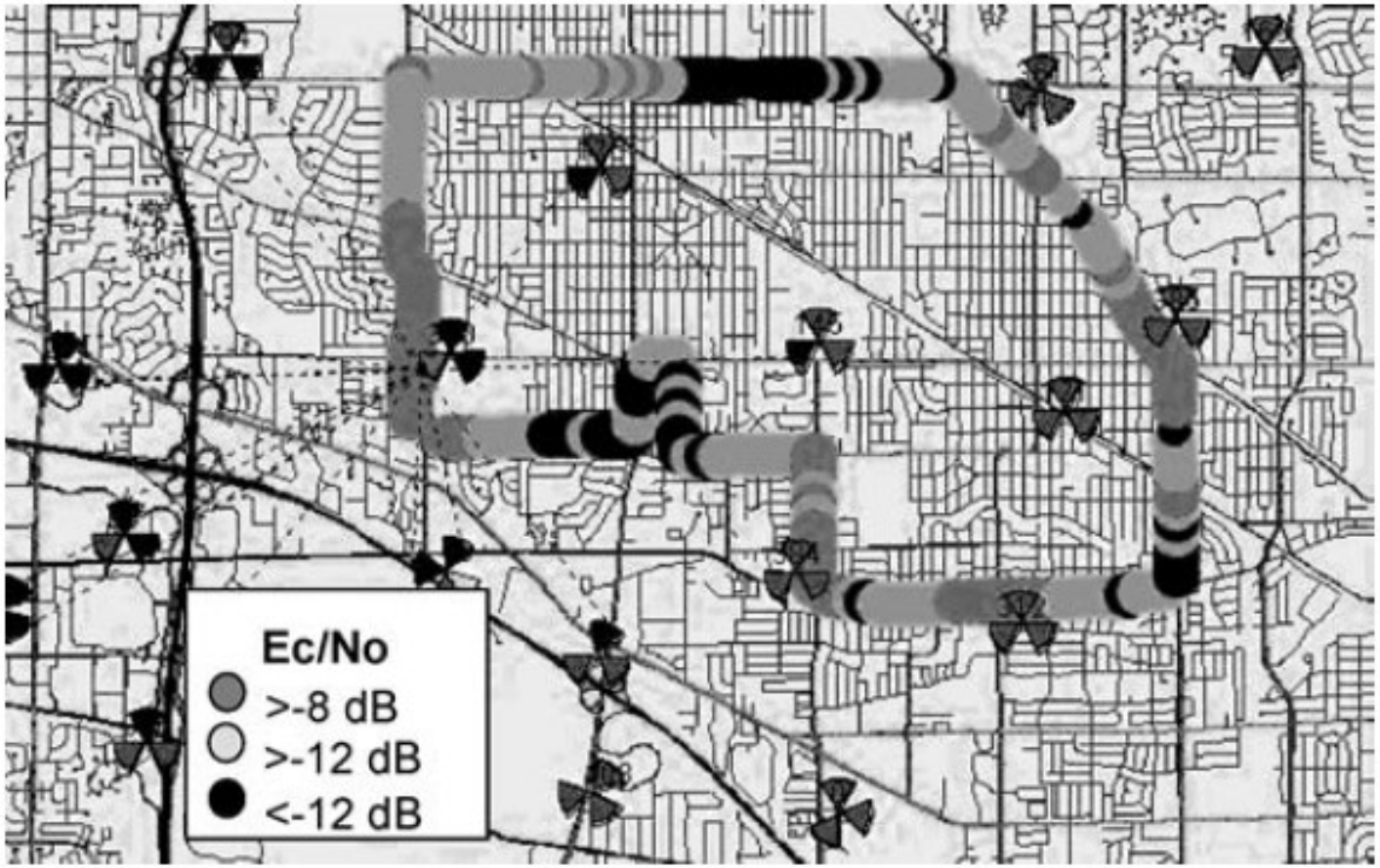
Example radio conditions (Ec/No) in a cluster from a drive test measurement



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Drive test: second level KPIs

- **Total packet switched establishment time**, setup time should be around 2 sec
- **Application level throughput**, in good radio conditions, the bitrate should be limited by the device capability, NodeB baseband configuration and Iub backhaul resources
- **Latency (Round Trip Time),** under ideal conditions, the RTT should be close to 90 ms for HSDPA/Rel.'99 DCH, and 70ms for HSDPA/HSUPA
- **Packet drop call rate in stationary conditions and during cell reselection:** packet drops in good radio conditions indicate a problem.
- **Voice performance:** assess voice quality when data services are present (BLER, drops, access failures)

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Appropriate optimization actions should be taken for identified problems from OSS and drive test results

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Note

- Although all infrastructure vendors provide a set of default parameters as a starting point for the operation of the network, the operator will have to adjust some of these to their specific situation
  - Parameters for Basic Activation Features (Enable HSDPA, HSUPA, 64QAM, …)
  - Parameters for Control of Resources (HSDPA code, HSDPA power, ..)
  - Parameters for Mobility management (e.g Enable Cell Selection to HSDPA Layer)
  - Parameters for Performance (e.g. HSDPA Scheduler type, HSDPA/HSUPA HARQ type, …)