“CDMA radio network optimization methods and tools”

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Outline

- Motivation
- Definition
- Optimization dynamics
- Optimization tools
  - Statistical data
  - Online measurements
  - Field measurements

Motivation

- Efficient network deployment and exploitation
  - Better solutions for engineering problems
  - Integrating technical issues in the whole picture: management models
- As any process: environment in which exists, "transfer function" and "state machine" of the particular system area (who interacts with who, information flows, external stimuli)

Definition

- Optimization: set of processes (manual or automated) by which the network performance is altered, according to some previously defined objective, and whose results are analyzed to judge the degree of success

- Classification: According to the amount of data required as input and the time needed to produce a measurable result
  - Slow loop: offline optimization based on long term statistical data (e.g., adding a site or indoor solution)
  - Fast non real time loop: dynamic control of system internetworking (eg GERAN, UTRAN), self regulation of RN parameters (eg load thresholds), etc
  - Fast real time loop: fast power control, fast congestion control, link adaptation, channel allocation

From the operator model point of view...

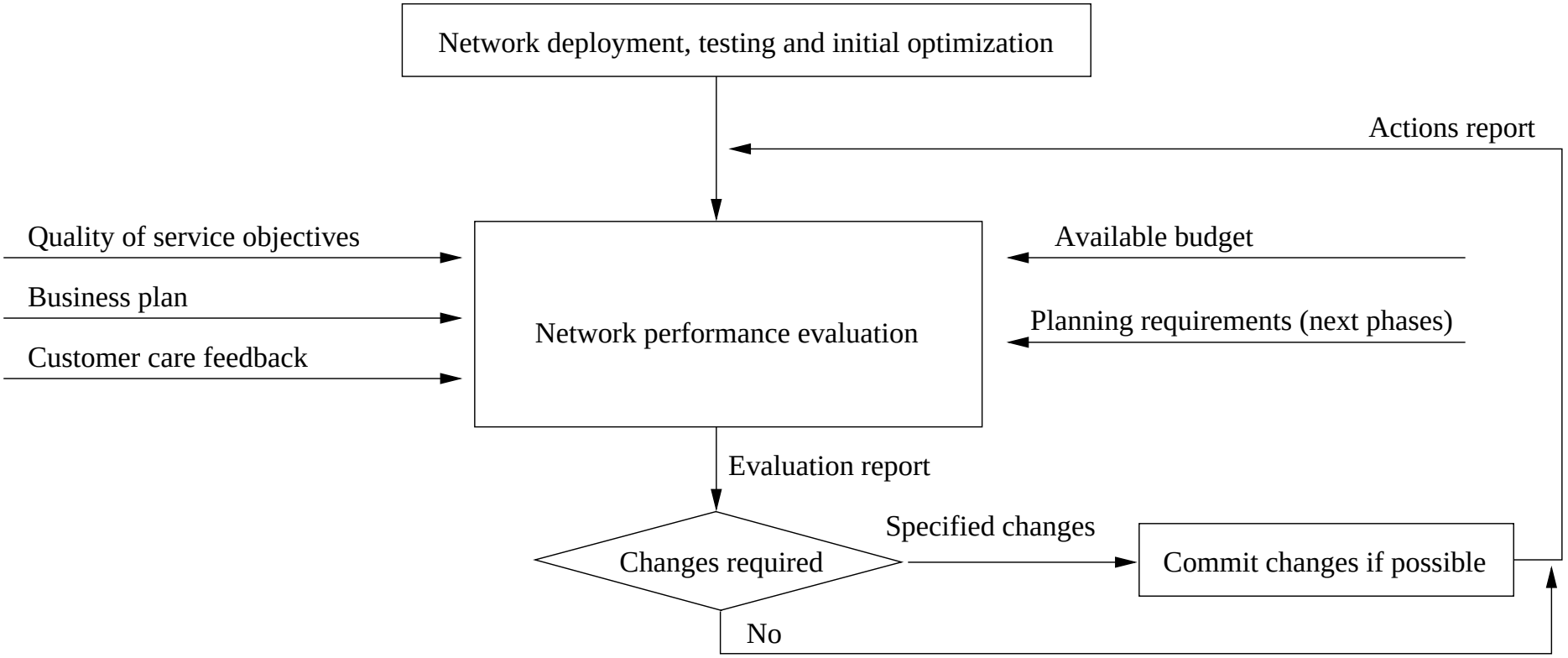

Figure 1: Optimization process within the network dynamic

Network quality cycle

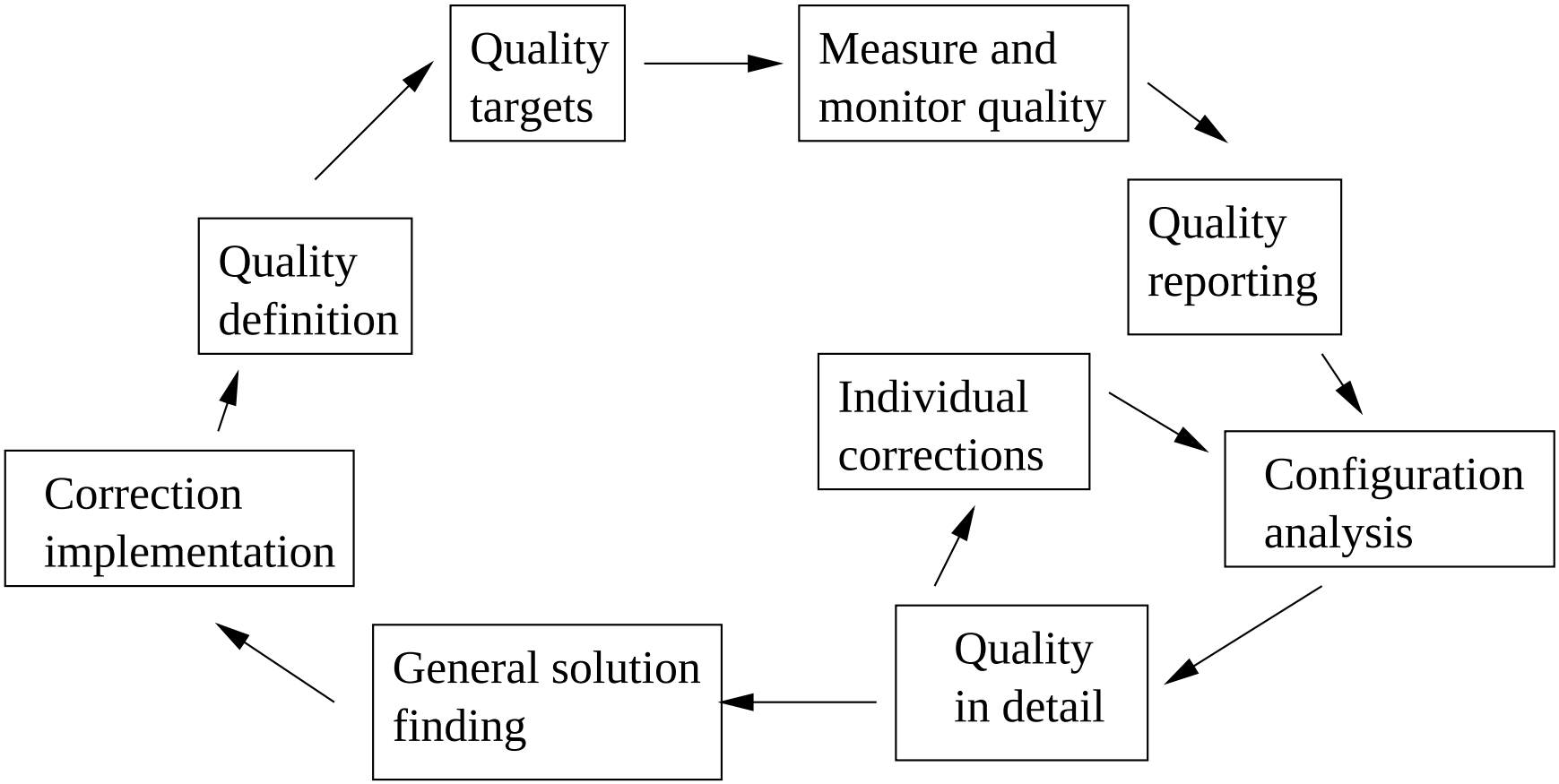

Figure 2: Network quality cycle

Events triggering Optimization

- QoS objectives not being met (constant supervision over KPI)
- Change in business plan (eg redistributing services between 2G and 3G, installing an indoor solution, etc)
- Preparing for next phase (eg modifying tilts or powers in some area to install a new site, in order to enlarge capacity)
- Specific problems found
  - Routinary network check
  - Customer care feedback

Optimization outputs

- Changes in network configuration
- Impact evaluation, over QoS (reflexed on KPI and field tests)
- Change log
- Reports to the triggering entity
  - Problem status (solved, unable to solve with available budget / suggestions)
  - Additional changes to previous service (eg, coverage improved, better transmisson speeds achievable, etc)

Tools in optimization: in fast real time loop

- Soft handover optimization: keeping handover overhead controlled (affects capacity and user perceived QoS)
  - Addition window: in order to include only the essential cells in the active set and avoid capacity reduction
  - Drop window: usually relative to addition window, complementing its work. Wrong parameter will cause wrong cells in the a.s. or "pingo pong" in and out
  - Maximum allowed active set size and drop timer: tune in a per cell basis, in order to adjust SHO overhead

- Power control: adjust P-CPICH power at around 5 to 10% of total BS power, in order to ensure P-CPICH coverage and avoid pilot pollution. Also select a proper PC algorithm (environment, average speed of the terminals)

Tools in optimization: in slow loop (1)

- Optimization in the detailed RNP phase
- "Pre optimization" with the digital map and simulators
  - Proper antenna selection and tilt configuration
  - Use of mast head amplifiers
  - Use of roll-out optimised configuration (sharing of power amplifiers between cells)

Tools in optimization: in slow loop (2)

- Optimization with statistical data: visualization
- Need for a tool for visualizing the key performance indicators (KPI) over a digital map
  - Thresholds for KPI's are set by QoS objectives (e.g. total percentage of blocked calls $< 2\%$, etc)
  - Tool should be flexible in order to change the thresholds, visualization options and even the KPI definitions
  - Most GIS software have the ability to query relational databases
  - Different areas are interested in differents KPI (blocked calls, dropped calls, rejected calls due to insufficient UL signal strength, soft handover failures, etc)

Tools in optimization: in slow loop (3)

- Optimization with statistical data: automatic monitoring of KPI
- KPI's should be continually monitored, with some alarm system (eg immediate report by sms) and reports available
  - KPI's set per cell or per cell clusters
  - Run on a configurable time basis (every day, hour, etc)
  - Same system also useful for hardware monitoring (fault detection), with proper indicators derived from counters

Tools in optimization: in slow loop (4)

- Interfaces and data flow in network wide optimization must be open, in order to have flexibility

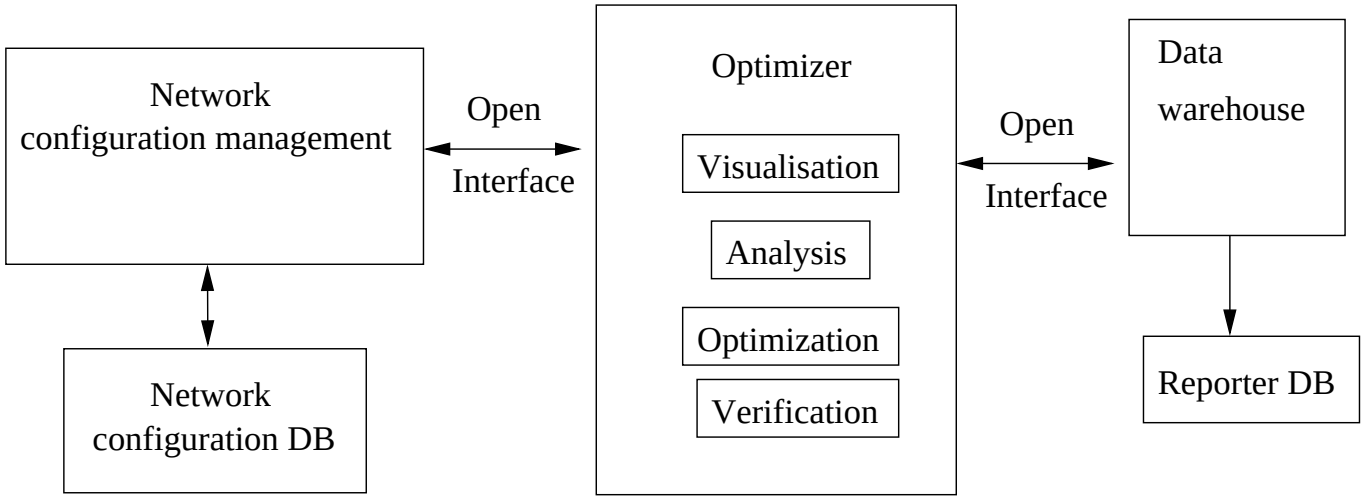

Figure 3: Need for open interfaces in data flow

Tools in optimization: in slow loop (5)

- Fault detection: hardware problems can be detected with RNC measurements
- Early and automated fault detection improve the user perceived QoS and also saves effort in diagnosing
- Example (TDMA world)
  - Faulty transmitters tended to have most of the erroneus bits in DL
  - This was not obvious with only the BER for the whole cell (adding erroneous bits from all transmitters)
  - One simple indicator was the percentage of erroneous bits in the transmitter, over the sum of all transmitter eroneous bits ("BER per transmitter")

Statistical data: radio network controller measurements

- Aim: reflect the performance of the Radio Network
- Measurements must be scheduled in the RNC (every day, on week days, staring hour, measurement time, cells involved, counters to be gathered)
- Raw counters grouped by classes
  - Service level (counters related to QoS)
  - Signalling (I_u, I_{ur}, I_{ub}, RRC signalling)
  - Traffic (counters related to admission control)
  - Radio performance (counters related to power control)
  - Radio resources (in each cell, related to admission/load control)
  - Handovers (intra/inter system, soft HO)

Statistical data: radio network controller measurements (2)

- Names should be standarized
- Explicit definition and reason for update must be provided, also relations to other counters, if any
- Storing: measurements can take a huge amount of space (specially in a big network). Data gathering process may fail for some elements.
  - Counters exhibit different behaviours: weekend/weekdays, morning-noon-night-loaded hour. Low traffic conditions may distort KPI values at cell levels
  - Storing raw counters allow to study new KPI and problems
  - Some sort of network change log must be kept in order to analize the historical network performance
  - For practical purposes, at least one month of previous history is needed
  - Failure in collecting data from some elements can distort statistical analysis and must be monitored
- Definition of KPI and full understanding of counters require comprehensive knowledge of the Radio Access Network

Statistical data: radio network controller measurements (3)

- Example of Key Performance Indicator (KPI)
- At cell level, the ability of the network to keep a normal connection to the end (eg a voice connection) may be measured by:

$$100 \frac{\text{dropped\_vcalls}}{\text{vcd\_before\_second\_attempt} + \text{vcd\_after\_second\_attempt}}$$

- Counter dropped_vcalls increases on each abnormal termination of voice connections, vcd_before_second_attempt and vcd_after_second_attempt increases when a voice call is stablished, at first and second attempt
- dropped_vcalls should be equal to the sum of other counters for voice connections, namely outgoing_handover_drops, insufficient_power_ul_drops, insufficient_power_dl_drops, insufficient_c_i_ul_drops, insufficient_c_i_dl_drops

Statistical data: radio network controller measurements (4)

- Online monitoring: if detailed information is required from a specific network element (eg uplink and downlink powers and load in a cell). Usually not required if relevant counters are defined for every hour

- Mobile/user tracing: detailed information from all the networks elements and interfaces. Useful for analyzing specific problems in a cell (coverage borders, fine handover adjustment, specific user/mobile problems at HLR, etc)

Uses for field measurement equipment

- Verify coverage, bit rates and general quality of offered service, both in loaded and unloaded network conditions
- Contrast coverage predictions with reality and refine propagation models, fine tuning of RF systems (tilt, antenna selection)
- Detecting cell borders and SHO regions, and tuning related parameters
- Keep P-CPCH powers balanced and avoid pilot pollution
- Propagation studies (with test transmitters) for new sites

Field measurement equipment minimum requirements

- Support for GPS, ideally with differential GPS for dense urban areas
- Software must be handled by a portable computer
- Interface to 3G terminals (the more supported terminals, the better)
- Measurement tool software to log and store data for off line processing, data exporting capabilities
- Post processing functions may be integrated with the collecting software
- Data and power connectivity (in the laptop)

Challenge for automation

- Monitoring or performance managing processes may trigger automated parameter tuning
- Some parameters may be automatically tuned with not so much loss of performance (compared to manual tuning), like total power targer, P-CPICH power, maximum DL link power, dedicated NRT/RT capacity
- Sets of parameters may be seen as the result of an optimization problem: $\{f_j(\lambda_1, \ldots, \lambda_n) \leq \mathrm{KPI}_j^*\}_{j=1}^n$ where λ_i are the network parameters and f_j some cost functions, given the KPI measurements and KPI_j^* targets
- Results of the optimization problem should be verified with a simulator
- It may not be easy to find cost functions that reflect the parameter impact accurately
- Network management shoud be "simpler and cheaper"

References and homework

1 J. Laiho et al., "Radio network planning and optimisation for UMTS", John Wiley & Sons Ltd., 2002

- Homework:
  - What is the main goal of the optimization process?
  - Which areas are related to it and how?
  - What are the main concerns about data in statistical optimization?
  - What is the role of the Key Performance Indicators (KPI)?