Failures and changes in cellular access networks; a study of field data

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Outline

- Introduction
- Incident and change management processes
- Data set analyzed
- Failure analysis
- Correlation between failures and changes
- Summary
Background

• Increasing competition in wireless and cellular access networks

• Cooperation are between network operators are become more advanced
  – Site sharing, houses, towers
  – Site infrastructure sharing; power, cooling
  – Transmission sharing/leasing
  – RAN sharing
  – Etc

• How does the cooperation affect the dependencies between the access networks?
GSM/UMTS network
- general view

- Various technologies and structures in transport network
- BSC and RNC might be co-located.
- Node B and BTS might be co-located
Operation and Maintenance - processes and actors

- Information Technology Infrastructure Library (ITIL)

- Configuration management
- Incident Management
- Change management
- Problem management

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Incident Management - schematic overview

- Incidents
  - Start and Stop
  - Root cause identification
  - Classification
  - Priority
  - Solution
  - Course of events for repair
  - Assignment to responsible
  - + lots of other fields

- Repair actions

- Incidents/alarms

- Third Party

- Maintenance centre

- Customers
  - Example
  - Coverage
  - Call drop
  - Quality

- Element/Network OSS
  - Example
  - Alarms as defined by vendor/supplier

- Network Statistics
  - Example
  - Outage effect as call minutes
  - Call overall completion rate
  - Traffic and performance

- Probes
  - Example
  - Signalling
Change Management - schematic overview

- **Radio Planning**
- **Infrastructure Planning**
- **Network Planning**
- **Transmission Planning**

**Config mgm Decision board**

- **Work Orders**
  - **Third Party**
  - **Access Operations**
  - **Field Engineers**
  - **Transmission Operations**

**Service Window**
- Dependent on risks
- Operator vs. Third party

**Work Orders**
- Several different types
- Organization oriented
- Affecting one or several equipment

**Network Changes**
Data set analysed; Incident and Changed records

• GSM/UMTS operator
  – Network keeps changing
  – Increasing usage

• Data set containing covering more than 1000 days
  – Several thousand BTS/NodeB
  – Network resources from BTS/NodeB to BSC/RNC
  – Several thousand incidents
  – Several thousand changes

• Normalization of numbers according to an “undisclosed constant”
Network incidents - mapped to service failures

What is a service failure?
- We have used the definition as used by the operator
- Operator's repair actions and processes are governed by the failure risk/consequences.
Service failure categorization - dependencies between actors

Category={Operator | Leased | Power}
Service failures vs. population density
- rural and urban areas

- Location ordered from rural to urban based upon inhabitants/area
- Maintenance window included

Note: conservative figures due to no relations to location configuration
Service failures vs. population density - rural/urban and actors

• Urban

Area group

% Of total number of failures

• Rural

% Of locations

- Area groups include same number of inhabitants
- Maintenance window included

Note: conservative figures due to no relations to location configuration
Periodicity of failures
- weekday and hour

- Week start on Sunday
- Maintenance window included
Periodicity of total number of failures - Discrete Fourier Transform

- The mean is not included
- Linear trend is removed before the discrete Fourier transform
Failures with common root cause  
- schematic overview
Common root cause - time differences in restoration

- Assume that a common root cause affects 5 locations
- We analyze time difference between when the first affected BTS/NodeB is restored and restoration times for the other affected BTS/NodeBs.

1 of 5 20%
2 of 5 40%
3 of 5 60%
4 of 5 80%
5 of 5 100%

\( t_1 = 0 \) \( \uparrow \) \( t_2 \) \( \uparrow \) \( t_3 \) \( \uparrow \) \( t_4 \) \( \uparrow \) \( t_5 \)
Failures with common root cause
- only included service “down”

A; 90% of the common root causes have restored 25% affected BTS/NodeB
B; After 10s median climbs towards 100%
C; After 100s 90% of common root cause have restored 50% affected BTS/NodeB;
D; After 200s 75% have restored 50% of the BTS/NodeB.
E; Expected proportion of restored BTS/NodeB after 70s is 75%.
Changes
- as defined by operator

- Granularity hour, given when last part of change is implemented
- Week start on Sunday.
- Box representing 50% IQR
- Middle, mean (+), near outliers (o) and far outliers (*)
Correlation changes and failures
Number of changes vs. failures

- Failures and changes related to radio excluded
- Only root cause failures for “service down” are counted
- Only change objective are counted
Summary

• The analysis of failures categorized into operator, leased services and power related gives new insight of potential dependencies between the different operators.

• The failure intensity is provided for rural and urban areas. This provides new insight of how failures impact on the actual services offered to the customers in rural and urban areas.

• An analysis of failures with common root cause, shows that restoration times for affected services are not identical.

• The number of changes in the network is significant compared with the number of failures.