Fault Tolerance in Wireless Networks
[Tipper2002]

Mrudula Putcha

Department of Electrical Engineering & Computer Science
Information Technology and Telecommunications Research Center
ResiliNets Presentation

KU

mrudula@ittc.ku.edu

Fault Tolerance in Wireless Networks

Abstract

This paper discusses fault tolerance and survivability techniques of wireless access networks. Survivability in wireless networks is different from wired networks. This is because the wireless environment and user mobility present unique difficulties. This paper emphasizes on these two issues while discussing possible survivability techniques.

Fault Tolerance in Wireless Networks

Outline

- Introduction
- Architecture
- Survivability Framework
- Survivability Analysis
- Survivability Strategies
- Conclusions
- References

Fault Tolerance in Wireless Networks

Introduction

- Introduction
- Architecture
- Survivability Framework
- Survivability Analysis
- Survivability Strategies
- Conclusions
- References

Fault Tolerance in Wireless Networks

Introduction

- Challenges include
  - Wireless channel, user mobility, power conservation
- Failure scenarios includes
  - Loss of Base Stations (BS), Mobile Switching Center (MSC)
  - Loss of link between BS-MSC
- Survivability metrics could be
  - Call blocking probability, call setup delay, lost user load
- Three categories of network survivability
  - Prevention
  - Network Design and Capacity Allocation
  - Traffic management and restoration

Fault Tolerance in Wireless Networks

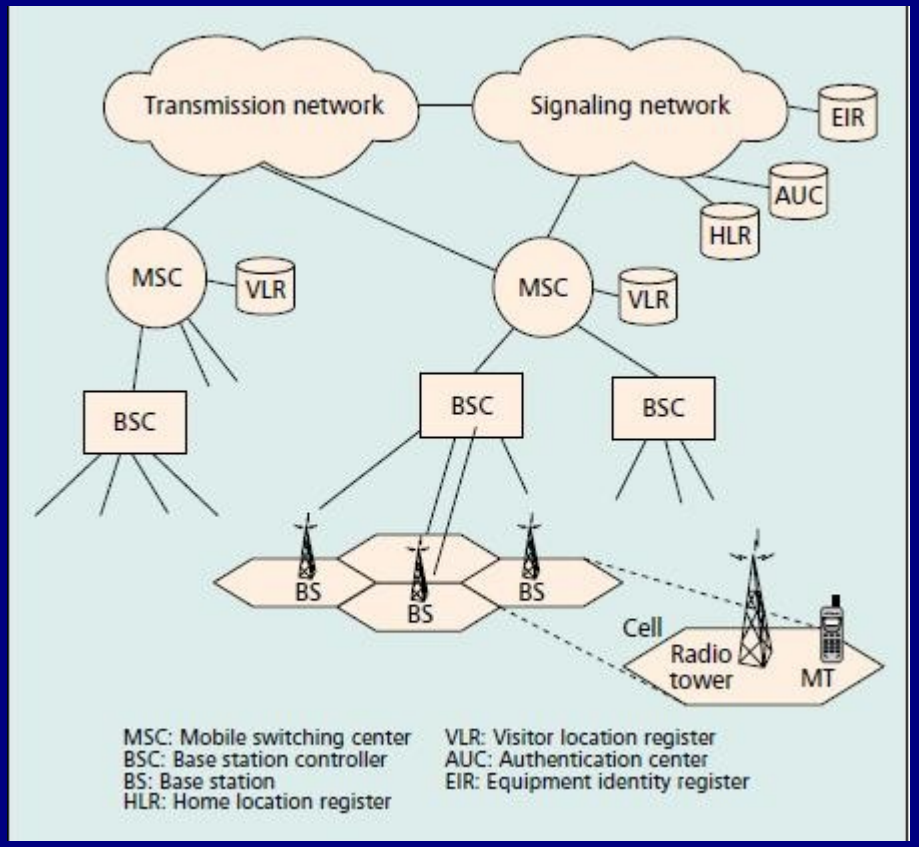
Architecture

- Introduction
- Architecture
- Survivability Framework
- Survivability Analysis
- Survivability Strategies
- Conclusions
- References

Wireless Access Network Architecture

Illustration

- Wireless access network architecture
- MSC- Mobile Switching Center
- BS- Base Station
- BSC- Base Station Controller
- HLR/VLR- Home/ Visitor Location Register



[Tipper-2002], Fig 1

Wireless Access Network Architecture

- Area divided into cells.
- Each cell served by a Base Station (BS)
- Wireless links between BS and Mobile Terminal (MT)
- Group of BSs managed by a BSC
- Connected to the backbone network via MSC
- MSC connected to transmission, signaling networks
- MSC also connected to VLR
- Other databases include
  - HLR, Equipment Identity Register (EIR)
  - Authentication Center (AUC)

Fault Tolerance in Wireless Networks

Survivability Framework

- Introduction
- Architecture
- Survivability Framework
- Survivability Analysis
- Survivability Strategies
- Conclusions
- References

Survivability Framework
Differences from Wired Network

- Wireless environment different from wired
  - Mobile wireless networks have to deal with mobility
  - Power conservation in mobile devices has to be considered
  - Wireless medium has poorer quality of links
- Channel capacity limited by regulated freq spectrum
- Survivability techniques
  - Existing survivability techniques designed for wired networks
  - Cannot be applied to wireless networks as it is
  - A different technique based on wired developed

Survivability Framework
Framework for Wireless Networks

- Three layer framework
  - Access Layer
    - Access radio layer- Defines communication over wireless link
    - Access link layer- Defines communication over landline part
  - Transport Layer- Call and mobility management
  - Intelligent Layer- Service and mobility management
- Each layer has different set of functions to perform
- Survivability metrics based on set of functions
- Survivability techniques based on impact of failure

Survivability Framework

Three Layers of Framework

Summary of functions of each layer

Layer	Components	Communication links	Function
Access radio level	Mobile units, base stations	Digital radio channels with TDMA, FDMA, or CDMA	Define physical interface for radio communication
Access link level	Base stations, BS controllers	Wireline links and/or terrestrial microwave	BS cluster management, radio channel management
Transport	BS, BSC, MSC, signaling network	Wireline links and/or terrestrial microwave, SS7 wireline links	Call/connection management, mobility management
Intelligent	MSC, HLR, VLR, EIR, AUC, signaling network	Wireline links and/or terrestrial microwave, SS7 wireline links	Service management, mobility management

[Tipper-2002], Table 1

Survivability Framework
Failure Scenarios and Impact at Each Layer

- Access Layer
  - Loss of a BS
  - This could impact entire cell and nearby cells
  - Call blocking probability, forced call termination probability
- Transport Layer
  - Loss of BSC-MSC link
  - Impact on a cluster of cells
  - Additional metrics like call setup/release delay
- Intelligent Layer
  - Loss of VLR
  - Lost user load and information accuracy

Survivability Framework

Failure Scenarios and Survivability Metrics

Typical failure scenarios and metrics summarized below

Layer	Failure scenario	Potential impact	Possible metrics
Access	Loss of BS	Partial/full service loss in cell, increased traffic in cells adjacent to failure	Call blocking probability, forced call termination probability
Transport	Loss of BSC-MSC link	Partial/full service loss in a cluster of cells, increased traffic in cells adjacent to failure	Call blocking probability, forced call termination probability, call setup delay, call release delay, paging/location update/registration delays
Intelligent	Loss of VLR	Loss of roaming service in a MSC coverage area	Lost user load (Erlangs), database access delay, information accuracy probability

[Tipper-2002], Table 2

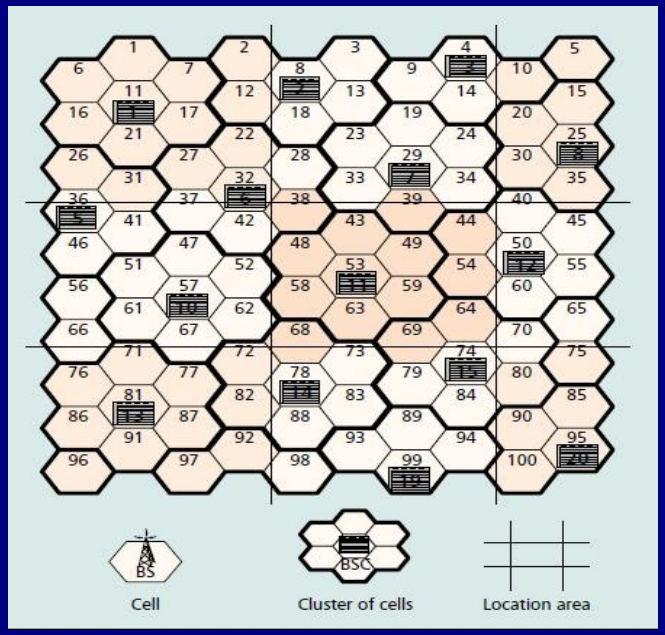
Fault Tolerance in Wireless Networks

Survivability Analysis

- Introduction
- Architecture
- Survivability Framework
- Survivability Analysis
- Survivability Strategies
- Conclusions
- References

Survivability Analysis
Specifications of the Simulation Model

- Simulation model to study failure scenarios
  - 100 cells/MSC with 1 VLR, 20 BSCs, 9 Location Areas (LAs)



[Tipper-2002], Fig 2

Survivability Analysis
Assumptions in Simulation Model

- Cell radius for a BS 3 km
- 62 radio channels in the system
- Frequency reuse cluster size of 7
- 8 time slots/channel and 1 control channel/cell
- Total of 70 traffic channels/cell

Survivability Analysis
Analysis Results

- Mean results for 10 minutes post failure

Metric	No failure	Four cells failure	BSC-MSC link failure
MOC blocking (%), P_o	1.64	9.57	15.5
MTC blocking (%), P_t	7.29	16.3	22.6
Location update delay (s), LD	0.257	5.23	3.85

[Tipper-2002],Table 3

Fault Tolerance in Wireless Networks

Survivability Strategies

- Introduction
- Architecture
- Survivability Framework
- Survivability Analysis
- Survivability Strategies
- Conclusions
- References

Survivability Strategies
Typical Survivability Strategies

- At the access radio layer
  - Overlapping cell sight architecture with freq reuse partition
  - Dynamic channel allocation algorithm and power control
- At the access link layer
  - Protection against landline link failure
  - BSC and BSs in cluster connected with a self healing ring
- At the transport layer
  - Mesh architecture between MSCs and BSCs
- At the intelligent layer
  - Database diversity, checkpoint protocols

Survivability Strategies

Typical Survivability Strategies

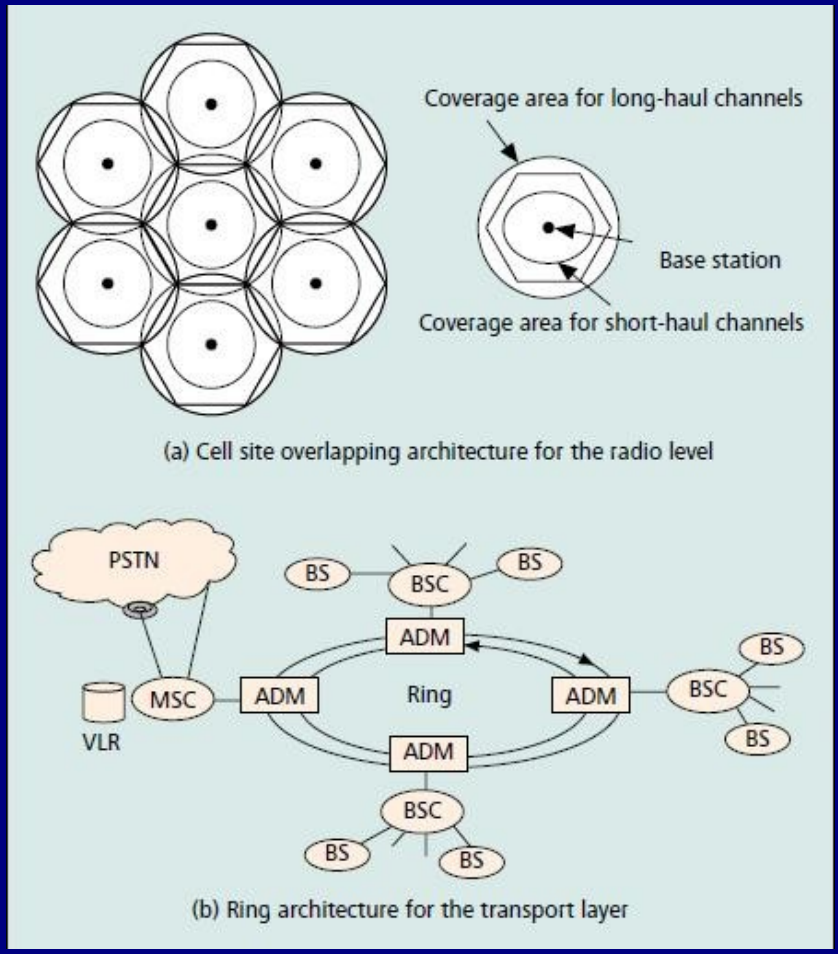
Survivability techniques at each layer

Layer	Robustness and redundancy	Traffic restoration
Access radio level	Spare RF components, overlapping/scalable cells	Load sharing protocols, dynamic channel allocation, adaptive channel quality protocols
Access link level	Spare BS-BSC link, multihoming BS to BSCs, ring topology for BS-BSC interconnect	Automatic protection switching, dynamic rerouting protocols, self-healing rings
Transport	Spare BSC-MSC link, ring topology for BSC-MSC interconnect, multihoming BSC to MSCs	Automatic protection switching, self-healing rings, dynamic rerouting, call gapping
Intelligent	Physical diversity in signal networking links, physical database diversity	Dynamic routing, checkpoint protocols

[Tipper-2002],Table 4

Survivability Strategies

- Overlapping cell site architecture for access layer
- Self healing architecture for transport layer



[Tipper-2002], Fig 3

Fault Tolerance in Wireless Networks

Conclusions

- Introduction
- Architecture
- Survivability Framework
- Survivability Analysis
- Survivability Strategies
- Conclusions
- References

Fault Tolerance in Wireless Networks

Conclusion

- Wireless networks need survivability strategies
- Challenges are different from wired networks
- A multilayer framework is suitable
- Unique characteristics of wireless network considered
- Possible failure scenarios discussed
- Typical survivability strategies suggested
- Strategies to be modified for different applications
  - Different strategy for date services and voice service

Fault Tolerance in Wireless Networks

References

- Introduction
- Architecture
- Survivability Framework
- Survivability Analysis
- Survivability Strategies
- Conclusions
- References

Fault Tolerance in Wireless Networks

References

- [Tipper-2002]- David W. Tipper, Teresa A. Dahlberg, Hyundoo Shin, and Chalermpol Charnsripinyo " Providing Fault Tolerance in Wireless Access Networks", *IEEE Communications Magazine*, vol.40, #1, January 2002, pp. 58–64