Call Admission Control in Wireless Networks

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Outline

— When, What, Why and How?
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— *Traditional* Wireless Call Admission Control Schemes
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— When, What, Why and How?
— Traditional Wireless Call Admission Control Schemes
— Modern Wireless Call Admission Control Schemes
Listen to his answers.

We found that if we didn't get there early, we didn't get a seat. It was like being in the fast lane, and we were the first to get there. It was a great feeling. I just love it. It's like being in the fast lane, and we were the first to get there. It was a great feeling. I just love it.
Customer Reaction
Customer Reaction
What Happens?
What Happens?
What Happens?

— Call blocking: at the initialization of a call
— Call dropping: at handoff (handover)
What Happens?

- New calls
  - Incoming handoff calls
  - Finished calls
  - Outgoing handoff calls
Why Call Admission Control?

— A wireless cell can only host a limited number of calls
— New calls and incoming handoff calls should not compromise the quality of the ongoing calls in the cell
— Limited bandwidth: Call admission control is more important in wireless networks
What is Call Admission Control?

Definition:

Call admission control is a technique to provide quality-of-service in a network by limiting the access to network resources [Ghaderi 06]
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Call admission control is a technique to provide quality-of-service in a network by limiting the access to network resources [Ghaderi 06]

Call admission control is a trade-off between:
— Maintaining the quality of the calls already in the network
— Accepting new users into the network
What is the Most Annoying?

— Your call is blocked
— Your call is dropped
What is the Most Annoying?

— Your call is blocked
— Your call is dropped

Incoming handoff calls need to be given priority over new calls!
A Simple Example - I

— A cell can only host 8 calls
A Simple Example - I

— A cell can only host 8 calls
— What happens with the new calls when the cell is full?
A Simple Example - I

— A cell can only host 8 calls
— What happens with the new calls when the cell is full?
— What happens with the incoming handoff calls when the cell is full?
A Simple Example - I

— A cell can only host 8 calls
— What happens with the new calls when the cell is full?
— What happens with the incoming handoff calls when the cell is full?
— How can incoming handoff calls be given priority?
A Simple Example - II

Solution:

— When the cell hosts 6 calls or more, new calls are blocked
A Simple Example - II

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— Only incoming handoff calls are given access to the cell if it has more than 6 calls
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Solution:
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— Only incoming handoff calls are given access to the cell if it has more than 6 calls
— The dropping probability decreases
— The blocking probability increases
Tradeoff: Call Blocking – Call Dropping
Limited to the Following...

— The standards only facilitate call admission control
— The call admission schemes used by Ericsson, Nokia, etc. are proprietary and are company secrets
— Focus: Basic system principles
— Authentication not handled
PART II: Traditional CAC Schemes
Traditional Wireless Call Admission Control Schemes

We focus on a GSM-like system with:
— Speech calls
— Fixed number of resources per call
— Hard handoff
— No call priority
Traditional Wireless Call Admission Control Schemes [Olivre 04, Ahmed 05, Ghaderi 06]

1. Guard channel reservation schemes
Traditional Wireless Call Admission Control Schemes [Olivre 04, Ahmed 05, Ghaderi 06]

1. Guard channel reservation schemes
2. Channel borrowing schemes
Traditional Wireless Call Admission Control Schemes [Olivre 04, Ahmed 05, Ghaderi 06]

1. Guard channel reservation schemes
2. Channel borrowing schemes
3. Call queuing schemes
Guard Channel Reservation Schemes

[Ahmed 05, Ghaderi 06]
Guard Channel Reservation Schemes

[Ahmed 05, Ghaderi 06]
Fixed Guard Channels [Hong 86]

N=New calls
H=Incoming handoff calls
Guard Channel Reservation Schemes

[Ahmed 05, Ghaderi 06]

Guard Channel Reservation

Static Number of Guard Channels

FIXED GUARD CHANNELS
Guard Channel Reservation Schemes

[Ahmed 05, Ghaderi 06]

Guard Channel Reservation

Static Number of Guard Channels

- Fixed Guard Channels

Dynamic Number of Guard Channels

Single Cell

Reactive
Guard Channel Reservation Schemes

[Ahmed 05, Ghaderi 06]
Fractional Guard Channels [Ramjee 97]

- Probability of accepting new calls vs. Maximum number of channels
- Number of occupied channels

Graph showing the relationship between the probability of accepting new calls and the maximum number of channels.
Guard Channel Reservation Schemes

[Ahmed 05, Ghaderi 06]

Guard Channel Reservation

Static Number of Guard Channels

- FIXED GUARD CHANNELS

Dynamic Number of Guard Channels

- Single Cell

- Reactive
  - FRACTIONAL GUARD CHANNEL
Guard Channel Reservation Schemes
[Ahmed 05, Ghaderi 06]

Guard Channel Reservation

Static Number of Guard Channels
  FIXED GUARD CHANNELS

Dynamic Number of Guard Channels
  Single Cell
    Reactive
      FRACTIONAL GUARD CHANNEL
    Predictive
Guard Channel Reservation Schemes

[Ahmed 05, Ghaderi 06]

Guard Channel Reservation

Static Number of Guard Channels
- **FIXED GUARD CHANNELS**

Dynamic Number of Guard Channels

Single Cell
- Reactive
  - **FRACTIONAL GUARD CHANNEL**
- Predictive
  - **LOCAL TRAFFIC PREDICTION**
Guard Channel Reservation Schemes

[Ahmed 05, Ghaderi 06]
Static Clusters
Cells Interconnected by Wires
Guard Channel Reservation Schemes

[Ahmed 05, Ghaderi 06]
Guard Channel Reservation Schemes

[Ahmed 05, Ghaderi 06]
Guard Channel Reservation Schemes

[Ahmed 05, Ghaderi 06]
Guard Channel Reservation Schemes

[Ahmed 05, Ghaderi 06]
Centralized Control
Guard Channel Reservation Schemes

[Ahmed 05, Ghaderi 06]
Guard Channel Reservation Schemes

[Ahmed 05, Ghaderi 06]

Guard Channel Reservation

Static Number of Guard Channels

- FIXED GUARD CHANNELS

Dynamic Number of Guard Channels

Single Cell

- Reactive
  - FRACTIONAL GUARD CHANNEL

- Predictive
  - LOCAL TRAFFIC PREDICTION

Cluster

- Static
  - NEIGHBORING CELL STATE

- Dynamic
  - VIRTUAL CONNECTION TREE
Guard Channel Reservation Schemes

[Ahmed 05, Ghaderi 06]
Shadow Clustering [Levine 95]
## Qualitative Comparison [Ghaderi 06]

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<td>Low</td>
<td>Low</td>
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<td>Neighb. Cells State</td>
<td>Moderate</td>
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<td>High</td>
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Channel Borrowing Schemes [Anderson 73]
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Call Queuing Schemes [Hong 86]
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— In real-life networks, cells are overlapping
Call Queuing Schemes [Hong 86]

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— Queuing of handoff calls when all channels are occupied
Call Queuing Schemes [Hong 86]

- In real-life networks, cells are overlapping
- Queuing of handoff calls when all channels are occupied
- Call dropping probability is reduced
PART III: Modern CAC Schemes
Modern Wireless Call Admission Control Schemes [Niyato 05, Jemaa 05]

— Multiple classes of services
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— Heterogeneous networking: vertical handoff
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Modern Wireless Call Admission Control Schemes [Niyato 05, Jemaa 05]

- Multiple classes of services
- Heterogeneous networking: vertical handoff
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- Soft handoff
Modern Wireless Call Admission Control Schemes [Niyato 05, Jemaa 05]

— Multiple classes of services
— Heterogeneous networking: vertical handoff
— Integrated radio resource management
— Cross-layer design
— Soft handoff
— Trend: More adaptation
Multiple Classes: Multiple Cutoff Priority

[Li 98]

![Graph showing probability of accepting new calls vs. maximum number of channels for three classes.]

- **CLASS 1**: Probability of accepting new calls is 1, regardless of the number of occupied channels.
- **CLASS 2**: Probability of accepting new calls is 1 when there are no occupied channels, and 0 otherwise.
- **CLASS 3**: Probability of accepting new calls is 1 when there is 1 occupied channel, and 0 otherwise.
Multiple Classes: Thinning Scheme

[Fang 03]
Heterogeneous Networking: Vertical Handoff [Niyato 05]
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Heterogeneous Networking: Vertical Handoff [Niyato 05]
Integrated Radio Resource Management

- Adaptive Transmission
- Opportunistic Scheduling
- Admission Control and Handoff
Cross-Layer Design [Niyato 05]

- Low call blocking
- High call quality
- Low call dropping

[Diagram showing a triangle with the above three points and an 'X' mark on the low call dropping point]
Soft Handoff [Ghaderi 06, Hills 04]

— In real-life networks cells are overlapping
Soft Handoff [Ghaderi 06, Hills 04]

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— In some networks it is possible to communicate with two base-stations simultaneously
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Soft Handoff [Ghaderi 06, Hills 04]

— In real-life networks cells are overlapping
— In some networks it is possible to communicate with two base-stations simultaneously
— Makes handoff more reliable: *load sharing*
— *Multi-cell diversity* can be exploited
Trend: More Adaptation [Niyato 05]

— Measurements of more parameters
Trend: More Adaptation [Niyato 05]

— Measurements of more parameters
— Prediction of more parameters
Trend: More Adaptation [Niyato 05]

— Measurements of more parameters
— Prediction of more parameters
— More knowledge exchange
Call Admission Control in UMTS [Jemaa 05]

— Soft capacity
Call Admission Control in UMTS [Jemaa 05]

— Soft capacity
— Interference-level, packet error rate and load in neighboring cells are measured and collected
Call Admission Control in UMTS [Jemaa 05]

- Soft capacity
- Interference-level, packet error rate and load in neighboring cells are measured and collected
- Interference-based admission control
Call Admission Control in UMTS [Jemaa 05]

— Soft capacity
— Interference-level, packet error rate and load in neighboring cells are measured and collected
— Interference-based admission control
— Thinning scheme
Call Admission Control in UMTS [Jemaa 05]

— Soft capacity
— Interference-level, packet error rate and load in neighboring cells are measured and collected
— Interference-based admission control
— Thinning scheme
— Different QoS classes


Yuguang Fang. *Thinning Schemes for Call Admission Control in Wireless Networks.*
Majid Ghaderi & Raouf Boutaba. 
*Call admission control in mobile cellular networks: a comprehensive survey.*

A. Hills & B. Friday. 
*Radio resource management in wireless LANs.*

D. Hong & S. S. Rappaport. 
*Traffic Model and Performance analysis for cellular mobile telephone systems with prioritized and nonprioritized handoff procedures.*

Sana Ben Jemaa.  
*Gandalf D4.1 – RRM algorithms for wireless systems.*  
Rapport technique, Celtic Telecommunication Solutions, 2005.

David A. Levine, Ian F. Akyildiz & Mahmoud Naghshineh.  
*The Shadow Cluster Concept for Resource Allocation and Call Admission in ATM-Based Wireless Networks.*  

Bo Li, Chuang Lin & Samuel T. Chanson.  
*Analysis of a hybrid cutoff priority scheme for multiple classes of traffic in multimedia wireless networks.*  
Dusit Niyato & Ekram Hossain.  
*Call Admission Control for QoS Provisioning in 4G Wireless Networks: Issues and Approaches.*  

Alan Olivre.  
Call admission control and dynamic pricing in a GSM/GPRS cellular network.  

R. Ramjee, D. Towsley & R. Nagarajan.  
*On Optimal Call Admission Control in Cellular Networks.*  