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Communications Systems
Support in CDMA Based Wireless
Simultaneous MAC Packet Transmission: QoS

Technical University Berlin
Chair of Telecommunications Networks

Frank H. P. Fitzek
Contents

- Conclusion & Outlook
- Performance Evaluation
- Simulation Model
- SMTP
- Overview CDMA
- Motivation and Problems

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Furthermore QoS requirements become also time-variable because of different applications. QoS requirements become heterogeneous traffic will not be voice dominated anymore. Systems customer expects the same communication service known from wireline new degree of freedom makes wireless terminals very attractive.

Motivation – Status Quo

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Motivation – An example
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and outage periods

Conflicts with error characteristics of the wireless link (higher BEP)

<table>
<thead>
<tr>
<th>Based on UDP</th>
<th>Based on TCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>delay sensitive</td>
<td>delay insensitive</td>
</tr>
<tr>
<td>loss tolerant</td>
<td>zero loss</td>
</tr>
<tr>
<td>( {\text{VLC, VAA, video, audio}} )</td>
<td>( {\text{FTP, WWW, email}} )</td>
</tr>
</tbody>
</table>

\( \text{Real Time Services} \)  
\( \text{Data Services} \)

major classes of multimedia services in the world of IP:

Motivation - Transport Protocols
TKN TCP Measurements

Problem: TCP over Wireless

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each additional active channel lead to system degradation

asynchronous CDMA is interference limited

asynchronous systems (uplink) use pseudo-noise sequences
asynchronous systems (downlink) use orthogonal sequences

multiple access capability is introduced by different spreading sequences

CDMA is a spread spectrum technique

Code Division Multiple Access
Channel Model

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minimize transmission power \( \iff \) saves power of mobile unit

- control the link quality

- minimize the interference to other cells \( \iff \) maximize the system capacity

- alleviate the near far effect problem

necessary transmitted power

interference level \( I_I^0 / \mathcal{E}_n \) between different users maintaining the minimum

Goal: Control the transmitted power of each user to achieve energy to

**Power Control - Goal**

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Power control is not ideal because of the readjusting time takes into consideration the dynamics of simultaneously used channels.

Adjusting the $E_b/I_0$ according to bit error rate measurements (over brief intervals)

- Outer loop
- Closed loop
- Open loop

1595: Power Control Loops at WT
misleading power control

variance in power leads to

QoS and Power Saving

mean value of power influences

– greater tiers about 40%

– first tier 36%

impact on neighboring cell

impact on own cell

Why power aspects?

Cell Interference

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Protocol Stack

Wireless Link

Physical Layer

Data Link Layer

Network Layer

Transport Layer

Application

UDP/TCP

LLC

MAC

W-PHY

Base Station

Terminal

Wireless Stack

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System under Study

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about transmission if segment's delay bounds can not be fulfilled

Layer
Packets of one segment are reassembled and passed to the transport

Transport layer
Packets (plus header) are transmitted over the wireless link

To each packet a header is added

MAC layer divides a segment into a group of packets

System under Study
Transmission (SMTP)

A more sophisticated approach is needed: Simultaneous MAC-Packet

Send and Wait

FEC wastes bandwidth in case of good channel state

ARG translates losses into delay due to retransmissions

Solution: Like ARG and FEC suffer by the following reasons:

Status Quiz
statistical multiplexing on the wireless link

Multiple channels only in error case (capacity economy)

Approach: Usage of multiple codes (CDMA) with same power level for dynamic allocation of additional channels for a single wireless terminal

Goal: Stabilization of QoS in terms of loss rate and jitter

SMT
SMPI Approach - Fast Healing

Data Link

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<table>
<thead>
<tr>
<th>Time</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channels Used</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>11</td>
<td>12</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Data Link**

SMPT Approach - Fast Start
SMPT Approach - Slow Start

Data Link
- 64000 bit/s channel
- Impact on overall number of used channels
- Different SMIP approaches
  - UDP based
- 64000 bit/s channel
- Variable background traffic
- Point2point communication
  - TCP based
- Two different simulation scenarios
  - TCP, MPEG-4 and H.263 traces, CBR
  - PTOLEMY and Network Simulator (NS)

Simulation Model
Upper bound of TCP throughput ($\chi_{out} = 0$)

Stabilized TCP throughput for SMPT (around 58000 bit/s)

58000 bit/s

Variable TCP throughput without SMPT ranging from 25000 bit/s up to

TCP-Throughput: Sequential vs. SMPT

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No TCP retransmissions with SMPT

Without SMPT high bit error rates lead to TCP retransmissions

Congestion window size equals to 1 indicates a TCP retransmission

TCP Congestion Window: Sequential Mode vs. SMPT
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Error</td>
<td>5%</td>
<td>Simulated</td>
</tr>
<tr>
<td>Confidence Level</td>
<td>95%</td>
<td></td>
</tr>
<tr>
<td>Background Noise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTT Good</td>
<td>540 ms</td>
<td>Wireless Link</td>
</tr>
<tr>
<td>RTT Bad</td>
<td>60 ms</td>
<td></td>
</tr>
<tr>
<td>Bit Rate</td>
<td>64 Kbit/s</td>
<td>Physical Layer</td>
</tr>
<tr>
<td>Spreading Gain</td>
<td>128</td>
<td></td>
</tr>
<tr>
<td>R max</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>T slot</td>
<td>24 ms</td>
<td></td>
</tr>
<tr>
<td>I DPDU/Slot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I byte</td>
<td>192</td>
<td></td>
</tr>
<tr>
<td>L DPDU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L segment</td>
<td>4800 byte</td>
<td>Data Link Layer</td>
</tr>
<tr>
<td>L segment</td>
<td>1-4000 byte</td>
<td></td>
</tr>
<tr>
<td>T max</td>
<td>240 ms</td>
<td></td>
</tr>
<tr>
<td>T max</td>
<td>600 ms</td>
<td></td>
</tr>
</tbody>
</table>

Simulation Parameters for CBR Traffic

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CBR Goodput for different SMFI approaches

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Power Control Results - Fast Start
Power Control Results - Slow Healing

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### CBR Performance Evaluation - Overview

#### Table: Performance Metrics

<table>
<thead>
<tr>
<th>Idle Period</th>
<th>Idle Period %</th>
<th>Overall Codes Rate</th>
<th>Segment Loss</th>
<th>Jitter Throughput</th>
<th>Goodput [bit/s]</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.11 .07</td>
<td>1.11 .07</td>
<td>[Var] {}</td>
<td>[Var] {}</td>
<td>[Var] {}</td>
<td>[Var] {}</td>
<td>Sequential</td>
</tr>
</tbody>
</table>

#### Columns:
- **Idle Period**: Time intervals.
- **Idle Period %**: Percentage of idle periods.
- **Overall Codes Rate**: Rate of overall codes.
- **Segment Loss**: Percentage of segment loss.
- **Jitter**: Jitter value.
- **Throughput**: Throughput value [bit/s].
- **Goodput**: Goodput value [bit/s].
- **Parameter**: Parameter type (Sequential).
Related papers and slides available on WWW server

- SiMPF approaches with small impact on power control entropy
- Higher performance gain with optimized power control
- SiMPF improves application performance
- CDMA communication systems using only a few parallel channels

Conclusion
Outlook

Improvements for parallel channels of one wireless terminal by optimizing spreading sequences

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Remote Socket Architecture

Local Socket Module

Export Socket Server

LAN
IP
TCP

Internet

LAN
IP
TCP

Application
User

Base-Station

User

Exchange commands

and results

Application
User

Wireless end-system

Distant end-system