Implementing VoIP over CDMA2000 1xEV-DO Rev A; Understanding System Performance and Requirements

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Key Points

- VoIP spectral efficiency looks promising
- Audio delay numbers comparable
- Reverse link limited, Forward link has extra capacity for data
- Tradeoff between air-interface capacity and delay
- Standards support for QoS exists: more is needed
- While IMS/MMD provides a solid framework for end-to-end VoIP services more work needed in signaling and interworking standards
### Performance Analysis Summary

<table>
<thead>
<tr>
<th>Air Interface</th>
<th>CDMA2000 1X (Circuit Voice)</th>
<th>CDMA2000 1xEV-DO-A (VoIP with 2-frame)</th>
<th>CDMA2000 1xEV-DO-A (VoIP with 2-frame)+MAC Mux</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice Delay M-M (msec)</td>
<td>250</td>
<td>268</td>
<td>248</td>
</tr>
<tr>
<td>Vocoder FER (1% RL + 2% FL-delay)</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Voice Erlangs (Voice only)</td>
<td>18-23 (mix)</td>
<td>30* (mix)</td>
<td>30* (mix)</td>
</tr>
<tr>
<td>Set-up Time M-M (sec)</td>
<td>8-10</td>
<td>9-11</td>
<td>9-11</td>
</tr>
</tbody>
</table>

- mix: Ped A/B, Veh A 3 km/h
- DO-A results assume mobile diversity; Additional capacity in the FL w/ MAC mux
- 2-frame bundling = Encapsulation of 2 EVRC frames into 1 RTP/UDP/IP packets
### VoIP Delay Components (2-Frame Bundling)

<table>
<thead>
<tr>
<th>Reverse Link = 183 ms</th>
<th>Forward Link = 150 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 ms</td>
<td>Voc Accum</td>
</tr>
<tr>
<td>20 ms</td>
<td>Voc Encoder</td>
</tr>
<tr>
<td>38 ms</td>
<td>BSC/PDSN Network/Core Mob-Mob = 248 ms</td>
</tr>
<tr>
<td>60 ms @ 30 Erlangs</td>
<td>Air (HARQ)</td>
</tr>
<tr>
<td>15 ms</td>
<td>Voc Encoder</td>
</tr>
<tr>
<td>40 ms @ 2-frm bundling</td>
<td>Voc Decode</td>
</tr>
</tbody>
</table>

- Reverse Link: 183 ms
- Forward Link: 150 ms
- 2-Frame Bundling: 40 ms
- 30 Erlangs: 30 ms

**Notes:**
- 10 ms: Voc Decode
- 20 ms: Voc De-jitter
- 38 ms: BSC/PDSN Network/Core
- 60 ms: Air (HARQ)
- 35 ms: BSC/PDSN Network/Core
- 15 ms: Voc Encode
- 20 ms: Voc De-jitter
- 40 ms: Voc Accum
- 10 ms: Voc Decode
Physical Layer Enhancements in CDMA2000 1x EV-DO-A

- **Reverse Link Enhancements**
  - **Higher data rates and finer quantization**
    - Support of data rates ranging from 4.8 kbps to 1.8 Mbps with 48 payload sizes
  - 4 slot sub-packets (6.66 ms)
  - Support of QPSK and 8-PSK modulation
  - **Hybrid ARQ using fast re-transmission (re-tx) and early termination**
  - **Flexible rate allocation at each AT via autonomous as well as scheduled mode**
  - Efficient VOIP support
  - 3-channel synchronous stop-and-wait protocol

- **Forward Link Enhancements**
  - **Peak rates increased from 2.4 Mbps to 3.1 Mbps**
  - **Multi-user packet support**
    - Creates additional small payload sizes (128, 256, 512 bits)
    - Improves frame fill efficiency
  - **Data Source Control (DSC) Channel introduced (on RL) to indicate the desired forward-link serving cell**
    - Minimize service interruption due to server switching on FL
Reverse Link Pole Capacity for 2-frame Bundling

vs. F-factor and Overhead Size

- F-factor or reuse efficiency represents the ratio of the same-cell to the total cell interference.
- Highly dependent on the channel and propagation model used. It also varies in the field.
- 11 bytes of overhead supported by the current standards. Additional work needs to be done by the industry to lower it down.

3B RLP + 3B Compressed Header + 5B PPP
Reverse Link Delay: 2 Frame Bundling, Ped-A+Ped-B+Veh-A, RF Delay only

- 30 users can be supported with RF delay of 60 ms with 11 byte overhead
Forward Link Delay:
2 Frame Bundling, Ped-A+Ped-B+Veh-A, RF Delay only, \textit{w/o} MAC Mux

- 30 users can be supported with RF delay of 65 ms
Forward Link Delay:
2 Frame Bundling, Ped A+Ped-B+Veh-A, RF Delay only, w/ MAC Mux

- MAC multiplexing of up to 8 users
- 45 Erlangs can be supported with RF delay of 45 ms
- Significant increase in capacity with MAC multiplexing
Erlang Capacity: Conclusions

• Capacity is limited by RL
• **30 VoIP (M2M) Erlangs** with a mixture of channels and 2 frame bundling with M2M delay of **less than 248 ms**
  – Good agreement on RL capacity between analytic and pole capacity equation
• **45-50 VoIP (M2M) Erlangs** in FL only with MAC multiplexing (up to 8 users), with 2-frame bundling.
• Two frame or no frame bundling is the desired mode of operation since gaps in speech will lead to inferior voice quality with loss of packets with frame bundling greater than 2.
• Mixture of VoIP and Web services can be supported.
  – Graceful degradation in data capacity as VoIP users are increased
• **~250 kbps of FL data traffic** with 25 Erlangs in both directions
  ⇒ Mobile diversity brings extra FL data throughput
• Advance receiver at the MS will further increase FL throughput
• Work in progress includes
  – More analysis of the VOIP system performance for Reverse Link using system simulator
  – Estimating capacity for 2-frame and no-frame bundling for mixes of traffic and channel types
  – Performance with advance receiver and RX diversity
QoS Landscape

- RAN transport QoS loosely coupled to application QoS
  - PPP hides application QoS from RAN IP transport
- Packet transport within the RAN need to be engineered to support application QoS requirements
- VoIP support across “QoS domains” previously not considered
- Applications (i.e. clients and servers) cannot signal QoS requirements in a standards based manner

AN and BTS backhaul classification and Scheduling

SDF may break application packets based on RLP requirements, if so, additional QoS marking is utilized
Illustration of the Need for QoS Over 1xEV-DO-A Backhaul

Average Backhaul Throughput and Backhaul 99.9 Percentile Delay

- Data only simulation results with FIFO queueing
- Offered traffic more bursty than in CDMA2000 1X
- Priority queueing necessary to satisfy VoIP delay requirements
  - Example: Single VoIP call mixed with data
Summary

• VoIP provides a viable way to utilize spare capacity on CDMA2000 1xEV-DO Rev A
  – Comparable call setup time
  – Tolerable voice path delay
  – Improved voice spectral efficiency over 1x (with receive diversity)
• There are currently significant issues that need to be addressed before providing a standards-based commercial deployment
  – Standards based VoIP call control
  – Inter-technology interworking standards
  – QoS
  – Backhaul
• Continuing investigations:
  – Voice delay and quality trade-offs with capacity
  – Mixed voice and data performance
  – QoS mechanisms
  – Core network and system features
  – Battery life