1xEV-DV Forward Link Overview
Key Aspects of Current 1xEV-DV Forward Link Design

• Fully maintains existing cdma2000 channels and signaling structure
• Set of fixed packet sizes (384, 768, 1536, 2304, 3072, and 3840 bits)
• Variable packet durations (1.25, 2.5, 5, and 10 ms)
• Channel sensitive scheduling
• C/I feedback rate of 800 Hz
• Scheduling time granularity of 1.25 ms
• Asynchronous retransmissions
• Adaptive modulation and coding with higher-level modulation schemes (QPSK, 8-PSK, and 16QAM)
  – Modulation can be changed for retransmission (asynchronous adaptive incremental redundancy—AAIR)
• Variable duration code-division multiplexed common control channels (1.25, 2.5, and 5 ms)
• Synchronous acknowledgements
• Using existing cdma2000 turbo codes, Quasi-Complementary Turbo Code (QCTC) interleaving
• TDM/CDM capability included, exact details under study
Forward Link Channel Structure

• Current 1xEV-DV design maintains backward compatibility with previous cdma2000 and IS-95 releases, i.e. existing channels are supported in 1xEV-DV

• Thus, a base station supporting an 1xEV-DV forward link can also support mobile stations conforming to
  – TIA/EIA/IS-95-A
  – TIA/EIA/IS-95-B
  – cdma2000 Revision 0
  – cdma2000 Revision A
  – cdma2000 Revision B
New Forward Link Channels

- **Forward Packet Data Channel (F-PDCH)**
  - Shared by packet data users
  - Consist of a number of code-division-multiplexed quadrature Walsh subchannels, each spread by 32-ary Walsh function

- **Forward Primary Packet Data Control Channel (F-PPDCCH)**
  - Used to indicate the Sub-packet Length (duration) of F-PDCH (and of F-SPDCCH implicitly)
  - Optional (when blind decoding on F-SPDCCH)

- **Forward Secondary Packet Data Control Channel (F-SPDCCH)**
  - Used to send the scheduled user’s MAC ID, ARQ Channel ID, Encoder Packet Size, and Sub-packet ID for most of the time
  - Used to broadcast available Walsh space information when needed
View of cdma2000 FL Channels

FORWARD CDMA CHANNEL (SR1)

Common Assignment Channels

CDM Pilot Channels

Common Power Control Channel

Synch Channel

Traffic Channel

Common Control Channel

Broadcast Control Channel

Paging Channels

Quick Paging Channels

Forward Primary Packet Data Control Channel

Forward Secondary Packet Data Control Channel

Forward Pilot Channel

TD Pilot Channel

Auxiliary Pilot Channels

Auxiliary TD Pilot Channels

Dedicated Control Channel

Fundamental Channel

Power Control Subchannel

Supplemental Channels

Forward Packet Data Channel
FL Channels Used in DV Data-Only Mode

- Existing common channels will be used when MS in idle and to transition MS to traffic state
- The MS can also be using other dedicated channels (e.g., F-FCH)
Reverse Link Channels that Support Forward Link Packet Data Operation

- **Reverse ACK Channel (R-ACKCH)**
  - ACK Channel to indicate to the base station whether a sub-packet transmitted on the F-PDCH was received successfully or not

- **Reverse Channel Quality Indicator Channel (R-CQICH)**
  - Used by the mobile station to indicate to the base station the channel quality measurements of the best serving sector
Basic Operation

(1) Rate Controlled Service (e.g. delay tolerant data)

(1) 1X-EV-DV common carrier BS

(2) Measure common continuous CDM pilot

(3) Send back C/I to 'best' sector

(3') Broadcast Walsh Space
Update as often as needed

(4) BS estimates $P_{PC}[k+1]$, and determines $P_{RC}[k+1]

(4') BS determines a $V_i[k+1]$ for all users $i$, and determines which rate controlled user will be transmitted

(5) At time $k$, BS allocates $P_{PC}' = P_{RC}'[k]$ to Rate Controlled users

(5') Data and Control Information

(6) Send back Ack/Nak

Legend:
$P_{PC}$ = Power for power controlled service
$P_{RC}$ = Power for rate controlled service
$V_i$ = priority function for user $i$
Forward Link Operation Overview (1)

- The BS transmit power and code space is dynamically shared between the rate controlled packet data users and power controlled circuit switched voice/data users.
- The Forward Link for the power controlled circuit switched voice/data is identical to cdma2000 1X.
- The rate controlled packet data users share a common channel with dynamically changing code space and power.
- Each 1xEV-DV mobile continually measures the C/I from all active BS’s using the continuous F-PICH. The mobile selects the best serving cell based on the measured C/I.
- The mobile transmits the C/I based on the serving sector pilot every 1.25 ms (cdma2000 power control group) back to the base station on the R-CQICH.
Forward Link Operation Overview (2)

- The BS determines the highest priority user(s)
- The BS collects the C/I feedback from all active users on the R-CQICH and schedules the transmission of the user control information and data to the users in a time-multiplexed/code multiplexed (primarily time-multiplexed) fashion
- The exact rate of the Forward Link transmission depends on the operation of the asynchronous and adaptive incremental redundancy operation
- The transmission rate is explicitly indicated to the mobile via the F-SPDCCH
- If the MS receives a transmission on the F-SPDCCH, the MS decodes the corresponding data packet on the F-PDCH
- If the mobile decodes the data packet on the F-FPDCH correctly, it sends an ACK (positive acknowledgement) to the BS. Otherwise, it sends a NACK (negative acknowledgement) to the BS
- The power control bits for the mobile’s reverse link operation are signaled via the IS-2000 F-CPCCH common power control channel
Example of AAIR Operation

- No synchronized timing relationship for retransmission
- Amount of redundancy can be varied in response to channel conditions
- Allows a flexible multiplexing of transmissions of different lengths
Forward Packet Data Channel

Forward Packet Data Channel Sequence → Add 16-Bit Packet CRC → Add 6-Bit Turbo Encoder Tail Allowance → Turbo Encoder R = 1/5 → QCTC Channel Interleaver → QCTC Symbol Selection

Encoder Packets

Add 16-Bit Packet CRC

Add 6-Bit Turbo Encoder Tail Allowance

Turbo Encoder R = 1/5

QCTC Channel Interleaver

QCTC Symbol Selection

Scrambler

QPSK/8-PSK/16-QAM Modulator

Symbol DEMUX I/Q Pairs 1 to N (N = 1 to 28)

32-Chip Walsh Subchannel Cover 1

Walsh Chip Level Summer

32-Chip Walsh Subchannel Cover N

A

B

I

Q

I

Q
Forward Packet Data Channel (cont’d)

Channel Gain

Walsh Chip Summer

Quadrature Spreading (Complex Multiply)

\[ I' = I \cdot P_{N_i} - Q \cdot P_{N_q} \]
\[ Q' = I \cdot P_{N_q} + Q \cdot P_{N_i} \]

Other Walsh Channels

Walsh Chip Summer

1.2288 Mcps

PN\_i

I-Channel

PN Sequence

1.2288 Mcps

PN\_q

Q-Channel

PN Sequence

1.2288 Mcps

Baseband Filter

\[ \cos(2\pi f_c t) \]

\[ \sin(2\pi f_c t) \]

Forward Modulated Waveform

\[ \sum \]
F-PDCH Channel Interleaving (QCTC)

- Interleaves sub-blocks
  - Maintains systematic bits in first group
  - Maximum number of systematic bits are transmitted in first subpacket
Forward Primary Packet Data Control Channel (optional)

F-PPDCCH Input (F-PDCH Subpacket Length) 2 Bits per 1.25-ms Slot

(3, 2) Block Encoder

Sequence Repetition (Factor = 4)

QPSK Modulator

3 Code Symbols per 1.25 ms

12 Symbols per 1.25 ms (9.6 ksps)

<table>
<thead>
<tr>
<th>F-PDCH Sub-packet Length (Number of 1.25-ms Slots)</th>
<th>Coded Symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>‘000’</td>
</tr>
<tr>
<td>2</td>
<td>‘101’</td>
</tr>
<tr>
<td>4</td>
<td>‘110’</td>
</tr>
<tr>
<td>8</td>
<td>‘011’</td>
</tr>
</tbody>
</table>
Forward Secondary Packet Data Control Channel

F-SPDCCH Input Sequence
(6-Bit MAC ID,
2-Bit ARQ Channel ID,
3-Bit Encoder Packet Size,
and 2-Bit Subpacket ID)
13 Bits per N Slots
(N = 1, 2, or 4)

Add 8 Error-Detection-Encoder Bits
Add 8 Encoder Tail Bits
K = 9 Convolutional Encoder
Symbol Repetition for N = 4
(Factor = 2)

21 Bits
29 Bits
R = 1/2
for N = 1
and
R = 1/4
for N = 2 or 4

58N Symbols

Puncture 10N Symbols
Quick-Skew (QPSK) Modulator

Block Interleaver

48N Symbols

48N Symbols
per N Slots
(38.4 kbps)
Operation of F-SPDCCH

• Three F-SPDCCH transmission durations (1.25, 2.5, and 5 ms)
• Indicate frame lengths of 1.25, 2.5, 5, and 10 ms
  – 5 and 10 ms frame lengths distinguished by different initializations of the CRC
• Code rates and repetition:
  – 1.25 ms: Rate $\frac{1}{2}$
  – 2.5 ms: Rate $\frac{1}{4}$
  – 5 ms: Rate $\frac{1}{4}$ with repetition before interleaving
• If F-PPDCCH is not present, do blind rate determination
• Fields in message
  – 2-bit ARQ Channel identity permits 4 parallel channels per mobile station
  – 2-bit sub-packet identity permits 4 groupings of encoded symbols to be transmitted
  – 3-bit encoder packet size (384, 768, 1536, 2304, 3072, and 3840 bits)
Forward Packet Data and Control Channel Operation

- F-PPDCCH
- F-SPDCCH
- F-PDCH

1.25 ms = 1 Slot

Leng th 1

Header 1

F-PPDCCH

F-SPDCCH

Sub-packet 1

H. 2

Sub-packet 2

Header 3

Sub-packet 3
Transmission of Walsh Information

- Send on F-BCCH
  - Indicator to use default Walsh space, or
  - Actual ordering of Walsh functions to be used
- Use all zero MAC ID on F-SPDCCH to indicate special control information
  - One special control information is the WALSH_SPACE

<table>
<thead>
<tr>
<th>32-ary Walsh Codes</th>
<th>(continued)</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>30</td>
</tr>
<tr>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>23</td>
<td>22</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>27</td>
<td>26</td>
</tr>
<tr>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>19</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>29</td>
<td>28</td>
</tr>
<tr>
<td>13</td>
<td>12</td>
</tr>
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<td>21</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>25</td>
<td>24</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
</tr>
</tbody>
</table>
Reverse Link Channels that Support Forward Link Packet Data Operation

- Channels are code multiplexed with existing cdma2000 reverse link channels
- Reverse ACK Channel (R-ACKCH)
  - ACK/NAK Channel to indicate to the base station whether a sub-packet and F-SPDCCH was received successfully or not
  - Transmitted off unless F-SPDCCH indicates that last subpacket was directed to the mobile station
  - ACK indicates that the packet sent on the F-PDCH was correctly decoded
  - NAK indicates that the F-SPDCCH was correctly received, but that the packet sent on the F-PDCH was not correctly decoded
- Reverse Channel Quality Indicator Channel (R-CQICCH)
  - Used by the mobile station to indicate to the base station the channel quality (C/I) measurements of the best serving sector
  - C/I quantized to a 5-bit value, referenced to Pilot Channel \( (E_{\text{pilot}}/N_t) \)
  - An 8-ary Walsh function (best sector indicator) corresponding to the best serving sector is used to cover the R-CQICCH transmission
  - Further spread by 16-ary Walsh code
Reverse Link Channels that Support Forward Link Packet Data Operation (cont’d)

CQI Symbols (FL Channel Quality Information)
One 5-Bit Symbol per 1.25-ms Slot

Encoder
R = 5/12

Signal Point Mapping
0 → +1
1 → −1

12 Binary Symbols per Slot

Walsh Cover Symbol
Wi
i = 0, ..., 7

CQI Cover Symbols (Best Sector Indicator)
One 3-Bit Symbol per 1.25-ms Slot

ACK Symbols
1 Bit per 1.25-ms Slot

Repetition (Factor = 24)

Signal Point Mapping
0 → +1
1 → −1

24 Binary Symbols per Slot

96 Binary Symbols per Slot

R-CQICH
(1.2288 Mcps)

R-ACKCH
(1.2288 Mcps)
Fixed Packet Size with Variable Packet Duration – Data Only (1)

Statistics on Slot Length (Payload Size)

<table>
<thead>
<tr>
<th>Payload Size</th>
<th>1-slot</th>
<th>2-slot</th>
<th>4-slot</th>
<th>8-slot</th>
</tr>
</thead>
<tbody>
<tr>
<td>384</td>
<td>0.852</td>
<td>0.119</td>
<td>0.009</td>
<td>0.020</td>
</tr>
<tr>
<td>768</td>
<td>0.653</td>
<td>0.217</td>
<td>0.051</td>
<td>0.079</td>
</tr>
<tr>
<td>1536</td>
<td>0.366</td>
<td>0.345</td>
<td>0.166</td>
<td>0.123</td>
</tr>
<tr>
<td>2304</td>
<td>0.221</td>
<td>0.405</td>
<td>0.247</td>
<td>0.127</td>
</tr>
<tr>
<td>3072</td>
<td>0.147</td>
<td>0.400</td>
<td>0.276</td>
<td>0.177</td>
</tr>
<tr>
<td>3840</td>
<td>0.048</td>
<td>0.299</td>
<td>0.384</td>
<td>0.269</td>
</tr>
</tbody>
</table>
Fixed Packet Size with Variable Packet Duration – Data Only (2)

Statistics on Slot Length (Traffic)

<table>
<thead>
<tr>
<th>Slot Length</th>
<th>WAP</th>
<th>HTTP</th>
<th>FTP</th>
<th>NRV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-slot</td>
<td>0.291</td>
<td>0.175</td>
<td>0.163</td>
<td>0.613</td>
</tr>
<tr>
<td>2-slot</td>
<td>0.300</td>
<td>0.362</td>
<td>0.368</td>
<td>0.231</td>
</tr>
<tr>
<td>4-slot</td>
<td>0.202</td>
<td>0.267</td>
<td>0.273</td>
<td>0.098</td>
</tr>
<tr>
<td>8-slot</td>
<td>0.207</td>
<td>0.196</td>
<td>0.196</td>
<td>0.058</td>
</tr>
</tbody>
</table>
Fixed Packet Size with Variable Packet Duration – Data and 50% Voice (1)

Statistics on Slot Length (Payload Size)

<table>
<thead>
<tr>
<th>Payload Size</th>
<th>1-slot</th>
<th>2-slot</th>
<th>4-slot</th>
<th>8-slot</th>
</tr>
</thead>
<tbody>
<tr>
<td>384</td>
<td>0.691</td>
<td>0.186</td>
<td>0.029</td>
<td>0.095</td>
</tr>
<tr>
<td>768</td>
<td>0.429</td>
<td>0.266</td>
<td>0.101</td>
<td>0.203</td>
</tr>
<tr>
<td>1536</td>
<td>0.168</td>
<td>0.319</td>
<td>0.242</td>
<td>0.272</td>
</tr>
<tr>
<td>2304</td>
<td>0.178</td>
<td>0.359</td>
<td>0.275</td>
<td>0.187</td>
</tr>
<tr>
<td>3072</td>
<td>0.063</td>
<td>0.292</td>
<td>0.348</td>
<td>0.298</td>
</tr>
<tr>
<td>3840</td>
<td>0.000</td>
<td>0.200</td>
<td>0.395</td>
<td>0.405</td>
</tr>
</tbody>
</table>
Fixed Packet Size with Variable Packet Duration – Data and 50% Voice (2)

Statistics on Slot Length (Traffic)

<table>
<thead>
<tr>
<th></th>
<th>1-slot</th>
<th>2-slot</th>
<th>4-slot</th>
<th>8-slot</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAP</td>
<td>0.179</td>
<td>0.268</td>
<td>0.233</td>
<td>0.321</td>
</tr>
<tr>
<td>HTTP</td>
<td>0.101</td>
<td>0.270</td>
<td>0.290</td>
<td>0.340</td>
</tr>
<tr>
<td>FTP</td>
<td>0.132</td>
<td>0.313</td>
<td>0.291</td>
<td>0.264</td>
</tr>
<tr>
<td>NRV</td>
<td>0.427</td>
<td>0.259</td>
<td>0.158</td>
<td>0.156</td>
</tr>
</tbody>
</table>
Study Items/Components

- Estimation of traffic to pilot ratio for F-PDCH and rate at which F-PDCH power can be varied (closed)
- Modulation schemes for retransmission
- Enhancements to IR
- Number of MAC ID
- Efficient C/I feedback (differential feedback)
- 64QAM
- Performance enhancements for small packets
- Fast Cell Selection
- 1.25 ms slot size
- Number of ARQ channels and possible relaxing of timing requirements
- Generating CRC with MAC ID
Component Proposals

- Antenna concepts
  - Adaptive antennas
  - 4-way transmit diversity
  - Selection Transmit Diversity (STD)
  - Multiple Input Multiple Output (MIMO)
  - Differential Measurement Metric (DMM)
- Cell Selection Soft Handoff
- LA and LS spreading codes
- Maintenance Channel
- Multiple Quality Control (MQC)