Presenters: Rashid Attar, Jun Wang

Enhancing machine-to-machine communications using 3GPP2 technologies
m2m is at the cusp of a major growth spurt...as wireless data in 1997 and Smartphones in 2006
Agenda

- how is cdma2000 (1x, 1x-EV-DO) being used for m2m today?
- m2m – what really matters?
- How do we enable explosive growth in m2m with 3GPP2 technology?
- Air-Interface Enhancements
- Network Evolution
m2m applications using cdma2000

Digital Payment Technologies
• Many parking operators report a very short cycle for return on their investment – typically 12-15 months

Remote Patient Monitoring and Health Care
• The success of CardioNet’s solution has driven a host of other remote patient monitoring solution providers into the market

Consumer Telematics
• DriveCam has helped save lives & reduce teen driving collisions by 70%

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• Eliminate ~50% of publishers’ operational expenditures.

Sea transport & shipping
• Companies need costal coverage with an increasing demand for high data speed
• Fishing, Passenger, Leisure, Freight

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m2m – what really matters?

- Lower power consumption + Excellent coverage
  - Increases in total addressable market (TAM)
  - Reduces cost for a target battery life

- Higher connection capacity
  - Enables operators to support more direct cellular m2m nodes with a given amount of network resource

- Solution cost
  - Module cost is just a component;
  - Network + Service + Maintenance cost are critical
How do we facilitate explosive growth of m2m w/ 3GPP2 technology?

- Promote use of existing technologies (and leverage coverage + network)
- Enhance the air-interface to improve battery life and connection capacity
- Evolve network architecture
Current 3GPP2 work in progress (for m2m)

- m2m numbering recommendations (SC.R4005)
- Enhanced m2m network specifications
- 1x-RevF (Enhanced Air-Interface for m2m)
- m2m study report
- m2m system requirements
Standards Focus (1/2)

- Battery Life
- Congestion and Overload Control
- Efficient handling of infrequent data transfers
- m2m server and network control of m2m client
- Fast re-authentication
Communication w/ m2m devices without an IP address

An external m2m device identifier

Group addressing, communication, and billing

Efficient test and certification processes
Air Interface Enhancements (cdma20001x Rev F)
- 1x air-interface is optimized for low-rate (voice, data) communications and 1x deployments (at 800MHz) have excellent coverage

- Most m2m apps are characterized by low-rate data and require good link budget

- 1x offers a cost-effective solution to meet the needs of a large % of m2m applications
Lower network cost + Higher network capacity + Improved module battery life enables 3GPP2 operators to aggressively promote use of m2m AND target new market segments.

Operators can leverage existing networks and maximize ROI by using 1x for m2m.
Direct Cellular

Characteristics
• 800-900MHz bands
• Licensed spectrum
• Deployed “everywhere” for voice communications
• Mature Networks

Benefits
• Excellent coverage
• No interference from unlicensed usage

Limitations
• Not designed for m2m
Example

- Simple app: 1x, m2m module uploads report (200 bytes) daily

![Diagram showing device states and time intervals for 3GPP2 cdma2000 workshop](image-url)
**Example (↓Signaling Load, ↓Data Transfer, ↑Battery Life ↑Connection Capacity)**

- Simple app: 1x, m2m module uploads report (200 bytes) daily

![Diagram showing power consumption and data transfer times for different scenarios.](image)

- **Device OFF**
  - Power UP
  - Call Setup
  - Data Xfer
  - Power DOWN
  - Using Traffic Channel (Baseline)
  - 0.8 sec
  - 0.06 sec
  - 0.5 sec
  - Data-driven dormancy
  - 6 msgs
  - 15 msgs
  - 200 B

- **Device OFF**
  - Power UP
  - Call Setup
  - Data Xfer
  - Power DOWN
  - 2 msgs

- **Device OFF**
  - Overhead Read
  - PPP Setup
  - Data Transfer
  - Wait for Network Dormancy
  - Idle State
  - Power Down Registration
  - Power DOWN
  - 1.28 sec
  - 1-1.5 sec
  - 2 sec
  - 0.2 sec
  - 10 sec
  - 0.5 sec

*Figure not to scale*
Simple app: 1x, m2m module uploads report (200 bytes) daily

-1.28 sec - 1-1.5 sec - 2 sec - 0.2 sec - 10 sec - 0.5 sec

Power UP Overhead Read Call Setup PPP Setup Data Transfer Wait for Network Dormancy Idle State Power Down Registration Power DOWN

Device OFF 6 msgs 15 msgs 900B 200B

Using Traffic Channel (Baseline)

Device OFF

Power UP Data Xfer Power DOWN

0.06 sec

Using Access Channel (Proposed)

Figure not to scale

Example (↓Signaling Load, ↓Data Transfer, ↑Battery Life ↑Connection Capacity)
The 1x air-interface is amenable to simple changes that enable an extremely efficient air-interface for m2m
Select Features and Qualitative Benefits
## Parameter Optimization

<table>
<thead>
<tr>
<th>#</th>
<th>Enhancement</th>
<th>MS</th>
<th>Spec</th>
<th>Primary Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Set Network Dormancy Timer for Data Service Options to a smaller value (e.g., 4 seconds)</td>
<td>N</td>
<td>N</td>
<td>i. Device Battery Life</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ii. Network Capacity</td>
</tr>
<tr>
<td>2</td>
<td>Increase # of RACH channels (up to 6)</td>
<td>N</td>
<td>N</td>
<td>i. Access Capacity</td>
</tr>
</tbody>
</table>
# Device-only changes

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<th>MS</th>
<th>Spec</th>
<th>Primary Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Device-Driven Dormancy</td>
<td>Y</td>
<td>N</td>
<td>i. Battery Life</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ii. Network Capacity</td>
</tr>
<tr>
<td>2</td>
<td>Network-friendly application development</td>
<td>Y</td>
<td>N</td>
<td>i. Battery Life</td>
</tr>
<tr>
<td></td>
<td>i. Minimize data transferred (e.g., update</td>
<td></td>
<td></td>
<td>ii. Network Capacity</td>
</tr>
<tr>
<td></td>
<td>location for a tracking application)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii. Avoid application layer ACKs (where</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>possible)</td>
<td></td>
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## Network SW Upgrade
(all features require new m2m modules)

<table>
<thead>
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<th>Spec</th>
<th>Primary Benefit</th>
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<tr>
<td>1</td>
<td>Increase PPP inactivity timer (for m2m devices)</td>
<td>Y (config–PDSN)</td>
<td>N</td>
<td>i. Device Battery Life</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y(SW Air-Int)</td>
<td></td>
<td>ii. Network Signaling Load</td>
</tr>
<tr>
<td></td>
<td>Ignore power down registration (from power-sensitive m2m devices)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Hierarchical Paging (1st page to last active set) + Direct Channel Assignment</td>
<td>Y</td>
<td>Y</td>
<td>i. Paging Capacity</td>
</tr>
<tr>
<td></td>
<td>(over F-PCH)</td>
<td></td>
<td></td>
<td>ii. Device Battery Life</td>
</tr>
<tr>
<td>3</td>
<td>Joint R-FCH and R-SCH request + assignment at connection setup</td>
<td>Y</td>
<td>Y</td>
<td>i. Device Battery Life</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ii. Network Signaling Load</td>
</tr>
<tr>
<td>4</td>
<td>Smart Blanking for data service option</td>
<td>Y</td>
<td>Y</td>
<td>i. Device Battery Life</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ii. RL capacity</td>
</tr>
</tbody>
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m2m solutions have a much longer life-span than the typical voice/data devices and the proposed solutions will open new market opportunities in the m2m space.
Metering Application
Module power consumption improvement

- Implementation only uses shorter preamble for with RACH

- Implementation + Stds
  - DoS w/ 38.4k R-EACH @ 0dBm
  - Connection w/ R-FCH @ 20dBm
Metering Application
Network Connection Capacity Increase

- Device-Driven Dormancy gains require application developers to use the available modem API
SmartGrid Connection Capacity
(1x module as an aggregator for 40 nodes)

- RL Capacity defined at RoT > 10dB, 1% of the time
  - Similar relative gains are observed at RoT > 7dB, 1% of the time
Network Evolution
Network Architectures

(A) Direct Communication Under 3GPP2 Operator Control

(B) M2M Service Provider Controlled Communication

(C) 3GPP2 Operator Controlled Communication
3GPP2 network architecture is good enough

- Can support 1x-RevF air-interface without any network architecture changes
  - No architecture change is required

- Required Configurations
  - Disable PPP session timer
  - Configure a long PPP session inactivity timer
  - Maintain PPP session through power-down registration
    - Device and RAN keep radio session
    - RAN keeps A10 so that PPP is maintained in the PDSN
m2m Architecture

- **M2M Server**
- **M2M-IWF**
- **HA/LMA**
- **MSC/VLR**
- **HLR/AC**
- **AAA**
- **USSD-GW**
- **IP-SM-GW**
- **SMS-SC**

**Network Components**
- **UE**
- **RAN**
- **PDSN**
- **M2M Application**

**Models**
- **Indirect Model**
- **Direct Model**
- **Hybrid Model**

**Control Plane and User Plane**
- Control plane
- User plane

**Protocols**
- SMS
- USSD
- IP

**Pathways**
- 1xCS SMS
- IP SMS
- SMS
- USSD

**Interconnections**
- HRPD or 1x
- A10/A11
- M2
- M3
- M4
- M5

**API**
Network Enhancements

- M2M-IWF as the interface to the M2M operator’s system hides 3GPP2 network topology and details
  - Shares common interface between IWF and M2M/MTC server

- Allow both CS and PS device trigger for handling infrequent Data Transmissions
  - CS trigger via SMS, USSD, etc
  - PS trigger through common A10 to allow eliminating PPP state maintenance in the UE and network
  - AAA/HLR may store mapping between external ID and internal ID

- IETF ERP (EAP Extensions for EAP-Re-authentication Protocol) based Fast Re-authentication
  - Speed up the data connection without requiring the PDSN to keep MS’s state
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