Requests for communication performance from connected vehicle of the future

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Market Back Ground for Future Communication

Global telecommunication market is apparently saturated after rapid expansion of recent 20 years
- Global penetration of communication equipment
- Cost reduction of hardware.
- Saturation of demand in traditional human use.

New market replacing Human to Human communication is needed to realize further growth.

Creation of Machine to Machine communication market having a size equivalent to human communication market.

Vehicle communication have been studied in recent 15 years
Home networking is also a candidate for M2M communication.

Recently Smart Grid attract interest as new market for machine to machine communication
<table>
<thead>
<tr>
<th>Year</th>
<th>Communication Terminals</th>
<th>Computers</th>
</tr>
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<tbody>
<tr>
<td>1950</td>
<td>$10^8$</td>
<td>$10^5$</td>
</tr>
<tr>
<td>1970</td>
<td>$10^9$</td>
<td>$10^7$</td>
</tr>
<tr>
<td>1990</td>
<td>$10^9$</td>
<td>$10^9$</td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td>$10^{11}$</td>
</tr>
<tr>
<td>2030</td>
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</tr>
</tbody>
</table>

Saturation of IT Market
contents

- Changes in IT environments
- Communication Services for vehicles
- Market Growth through M2M communication
Contents

- Changes in IT environments
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Traditional technology developments

- Communication technology has been developed starting from human communication in early stage.
- A lot of efforts are paid for improvement of performance and cost reduction.
- Multimedia applications for human market
- Broadband communication wireless and wireline
- Extension of range without repeater.
- Mobility management of human speed.
- Security to keep network
- Recent requests for low carbon systems
ITU-T Kaleidoscope 2010

Beyond the Internet? Innovations for future networks and services

Transmission speed

100M
10M
2M
1.5M
64k
32k
9.6k
2.4k
1.2k

Proposal of combination of multiple radios in 1994 in Japanese government report which is the source of contribution for B3G in 2002.

video
TV conference
G3FAX
PC communication
Voice
Short message

Service area

As a result of effort a lot of communication systems having different performance were developed.

Different systems have been developed mainly from seeds driven ideas.

Users are requested to cope with coexistence of different systems.

Use of combinations of different systems are responsibility of users.

Cognitive adaptation of user terminal is needed for smooth use of multiple systems, however this technology is far from reality.
Systems beyond IMT-2000 will encompass the capabilities of previous systems.

New capabilities of systems beyond IMT-2000

Dashed line indicates that the exact data rates associated with systems beyond IMT-2000 are not yet determined.

− Denotes interconnection between systems via networks, which allows flexible use in any environment without making users aware of constituent systems.

Nomadic/local area access systems

Digital broadcast systems

Dark shading indicates existing capabilities, medium shading indicates enhancements to IMT-2000, and the lighter shading indicates new capabilities of systems beyond IMT-2000.

The degree of mobility as used in this Figure is described as follows: low mobility covers pedestrian speed, and high mobility covers high speed on highways or fast trains (60 km/h to ~250 km/h, or more).
VAN diagram

MOBILITY

2G, 2.5G, 3G, 3.5G, 4G:

802.□□: IEEE

High speed

stationary

10k

100k

1M

10M

100M

1G

TRANSMISSION RATE (bps)
Current IMS based services are not suited for vehicular communication because separate systems do not have adequate coordination.
contents

- Changes in IT environments
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Advances in recent 10 years in ICT application for automobile

Traditionally ICT improved many aspects of vehicles including emission reduction and stability control. In recent 10 years, contribution of ICT in vehicle technology expanded fast.

Vehicle Stability Control
Radar Cruise Control (ACC)
Back Monitor
Tire Pressure Monitor
On Demand Information
Shift Control based on Map

Autonomous→Networked
Interests for Communication, V2I and V2V
Communication based services for safe smooth convenient operation

1970’s Signal control
1980’s Major improvements build in electronics for vehicle
1990’s DSRC for Infrastructure-Vehicle communication

  Traffic Data
  Toll Collection
  Congestion Charge

2000’s Transport Telematics

  Remote Vehicle Support system
  Map updating
  Music distribution
  eCall, e911

2005’s Vehicle Safety Systems

  Collision avoidance
ITS Vehicle services

- Traffic management
  probing, dynamic fee management, emission management
- Public transport management
  transit vehicle tracking, multimodal coordination
- Traveler information
  personal route guidance, provider based route guidance, dynamic rideshare
- Vehicle safety
  intersection safety warning, intersection collision avoidance, automated highway
- Commercial vehicle operation
  fleet administration, freight administration, electronic clearance, weigh-in-motion
- Emergency management
  stolen vehicle tracking, stolen vehicle control, emergency response, mayday support

ITS America, 1996
Two classes of vehicle communication

- **ITS (Intelligent Transport System)**
  - Vehicle services using short range communication
    - probing,
    - fee collection,
    - intersection safety warning

- **Transport Telematics**
  - Vehicle services using cell phone service
    - emergency management
    - stolen vehicle responses
    - remote vehicle support
    - personal route guidance
ITS Architecture

Travelers
- Remote Traveler Support
- Personal Information Access

Fixed point to fixed point Communications
- Wide Area Wireless (Mobile) Communications

Vehicles
- Vehicle
- Emergency Vehicle
- Commercial Vehicle
- Transit Vehicle
- Maintenance & Construction Vehicle

Centers
- Traffic Management
- Emergency Management
- Toll Administration
- Commercial Vehicle Administration
- Fleet & Freight Management
- Archived Data Management

Field
- Roadway
- Security Monitoring
- Toll Collection
- Parking Management
- Commercial Vehicle Check

ITS Architecture (ITS America1996)

- Travelers
- Centers
- Wide Area Wireless Communications
- Fixed Point to Point Communications
- Vehicle
- Field
- Vehicle to Vehicle Communications
- DSRC
Communication services for Vehicles

- When ITS study started in 1996, public wireless service was still premature.
- Dedicated short range communication system are proposed for ITS Communication.
- In latter half of 1990’s, cell phone services became ubiquitous and quickly saturated in personal service market.
- Transport Telematics was expected to cultivate new market for Cell Phone Carriers.
- In 1990’s business model of cell phone for Machine to Machine communication was still premature and performance was also inadequate for some of ITS applications.
Cell Phone for Vehicle Communication

- Business model to charge for car telecom module as the second personal cell phone did not work in 90’s.
- In 2000’s transport telematics is a auto-manufacturer based MVNO service and efforts are paid to promote providing useful services for automobile users.
- Although performance of Cell Phone does not satisfy the requirement for ITS, appropriate design to satisfy requirement should be possible if new market is possible in future.
- In 2000’s performance of LTE and 4G cell phone is expected to have performance for many vehicle applications.
Pune, India, 13 – 15 Dec 2010:
ITU-T Kaleidoscope 2010 – Beyond the Internet? Innovations for future networks and services
Round trip time and speed of B3G
Cell Phone standards can be unified after the history

- MOVA (1979)
- NMT (1981)
- AMPS (1982)
- PDC (1993)
- GSM (1993)
- cdma One (IS54) (1995)
- cdma2000 (IS95)
- TD-SCDMA
- WCDMA (2000)
- LTE → 4G (2010)

Time:
- 1975–1985: analogue
- 2005–2015: OFDM
Prediction of LTE (Japan)

![Chart showing prediction of LTE in Japan from 2009 to 2020, with projections for other technologies like WCDMA, HSPA, CDMA2000, and others.]
Prediction of LTE (US)
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Communication system for human use
Broadband communication wireless and wireline
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Extension of range without repeater.
Mobility management of human speed.
Security to keep network
Cost reduction by expansion of market
Recent requests for low carbon systems
Broad Range of Requirements for Machine to Machine Communication

Latency for Setup
- 0.1msec ~ 10msec ~ 1sec ~ 100sec

Distance of Communication
- 0.01m ~ 1m ~ 100m ~ 10km ~ 1000km

Data Speed
- 1b/s ~ 100b/s ~ 10kb/s ~ 1Mb/s ~ 100Mb/s

Coverage
- point, surrounding, linear, plane(operator, national, global)

Addressing
- location, person, vehicle, machine, situation

Error rate
- $10^{-9}, 10^{-7}, 10^{-5}, 10^{-3}, 10^{-1}$

Technology life
- 5 years, 10 years, 20 years, 100 years
An Example of Performance Requirement for Vehicle Service

Current Networks
Internet
POTS

Vehicle Networks

<table>
<thead>
<tr>
<th>distance</th>
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<tbody>
<tr>
<td>1m</td>
</tr>
<tr>
<td>100m</td>
</tr>
<tr>
<td>10km</td>
</tr>
<tr>
<td>1000km</td>
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<table>
<thead>
<tr>
<th>latency</th>
</tr>
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<tbody>
<tr>
<td>100sec</td>
</tr>
<tr>
<td>1sec</td>
</tr>
<tr>
<td>10msec</td>
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<tr>
<td>0.1msec</td>
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Communication performance requirement for intersection safety warning

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
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<tr>
<td>Latency for Setup</td>
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<tr>
<td>Distance of Communication</td>
<td>1m ~ 100m</td>
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<tr>
<td>Data Speed</td>
<td>100b/s ~ 10kb/s</td>
</tr>
<tr>
<td>Coverage</td>
<td>surrounding</td>
</tr>
<tr>
<td>Addressing</td>
<td>location</td>
</tr>
<tr>
<td>Error rate</td>
<td>10^{-5} ~ 10^{-3}</td>
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<tr>
<td>Life of technology</td>
<td>roadside 50 years</td>
</tr>
<tr>
<td></td>
<td>vehicle 20 years</td>
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<tr>
<td>Requirement</td>
<td>Specification</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>------------------------</td>
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<tr>
<td>Latency for Setup</td>
<td>10msec</td>
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<tr>
<td>Distance of Communication</td>
<td>1m ~ 100m</td>
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<tr>
<td>Data Speed</td>
<td>100b/s ~ 10kb/s</td>
</tr>
<tr>
<td>Coverage</td>
<td>surrounding, linear</td>
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<tr>
<td>Addressing</td>
<td>location</td>
</tr>
<tr>
<td>Error rate</td>
<td>$10^{-9} ~ 10^{-5}$</td>
</tr>
<tr>
<td>Life of technology</td>
<td>roadside 50 years</td>
</tr>
<tr>
<td></td>
<td>vehicle 20 years</td>
</tr>
</tbody>
</table>
### Communication performance requirement for mayday support

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latency for Setup</td>
<td>1 sec ~ 100 sec</td>
</tr>
<tr>
<td>Distance of Communication</td>
<td>10 km ~ 1000 km</td>
</tr>
<tr>
<td>Data Speed</td>
<td>10 kb/s ~ 1 Mb/s</td>
</tr>
<tr>
<td>Coverage</td>
<td>plane (global: cross border)</td>
</tr>
<tr>
<td>Addressing</td>
<td>vehicle, machine</td>
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<tr>
<td>Error rate</td>
<td>$10^{-5} ~ 10^{-3}$</td>
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<tr>
<td>Life of technology</td>
<td>roadside 50 years</td>
</tr>
<tr>
<td></td>
<td>vehicle 20 years</td>
</tr>
</tbody>
</table>
Business model of Cellular network to support small data traffic is needed.

Keeping track many terminals having low traffic is needed.

Possible number of vehicles to be served by cellular network is also be a problem.

Major issue for DSRC is difficulty in investment just for vehicle, especially in low traffic density area.

Common use of infrastructure for ITS and telematics will be a solution.

To keep the cost low for safety application is to be studied including new protocol common with another M2M services.

Study of common requirements for M2M communication is a challenge for new telecommunication market.