Automotive System and Software In Social Infrastructure

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Market Back Ground for Future Automobile

Global development of world economy
- Global penetration of communication equipment
- Cost reduction of hardware.
- Saturation of demand in traditional human use.

Efficient use of infrastructure
- Shared use of infrastructure different area by area
- Safety support of society in different environment

Continuation of advances of information Technology
- Continuation of Moore's Law
- Control of size of software to minimize faults
- Adaptation to digital native users
- Open service avoiding security concern

Green technology
- Low carbon technology

CONTENTS

- Automobile in infrastructure
- Information infrastructure to support automobile
- ITS and communication network
- Requirement to ICT from automotive technology
- Business model for ICT infrastructure for automobile

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History of Infrastructure

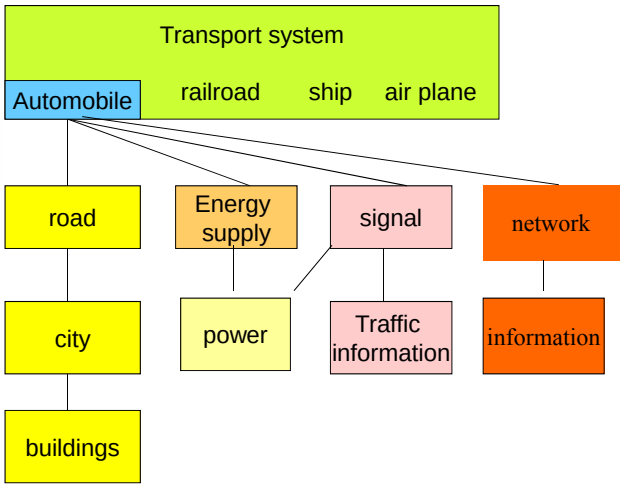
In history of human being society has been developed constructing variety of infrastructure.

- Infrastructure before industry
  City structure, road, highway, water supply system, drainage system
  Many of infrastructure improved environment created by nature. In these infrastructure life is expected to exceed 100 years

- .Infrastructure after industry.
  Different kind of infrastructure including rail road, telephone network, electrical power system and interurban highway have been constructed. These are constructed by user's money, and life is shorter. In early stage infrastructure are independently constructed and sharing is not common. As technology improved partial sharing can be possible.

- Information infrastructure
  Data networks and broadcast networks have been constructed independently. As technology advanced integration of use has been required but in many cases, regulation makes integaratin ndifficult in some country.

Infrastructure supporting automobile



Information systems in traditional automotive engineering

Information technology is key in variety of automotive technology

- Fuel economy/emission control (CO, CO2, NOx, evaporative emission)
- Vehicle dynamics total adjustment of control including handling, steering, braking and traction
- Safety engineering: seat belt bag control
- Drivability response of vehicle in various condition,

Software in broad area in automobile world

infrastructure	automobile	human
City	Manufacturing	Mobility
Building	Supplier	Convenience
Road	Inside car network	Safety
Highway	Distribution	Security
Energy	Maintenance	Privacy
Air	Operation	Fun
Power grid	Software	Market
Cloud		Human relationship
Network		Business
Control		Organization
Information		Software
Software		

Improvement of automobile through software engineering-Traditional concept

- Automobile is composed of variety of components supplied from many sources.
- Many of functionality of automobile are improved by mean of control software of each component.
- Traditionally components are designed and implemented independently.
- If integration of independently design components is possible, adaptation of products to satisfy variety of need will be economical.
- In this principle software of automobile should be implemented for each of components as much as possible.
- This strategy of software is suited to keep slim software.

Information technology to support automobile

- 1980s stand alone electronics: clean air, stability control
- 1990s car multimedia
- safety systems to control belt and baloon.
- 2000s use of ITS comfort, convenience and safety
- 2010s always connected automobiles
  information support of automobiles
  information sharing among remote and nearby automobiles
- 2020s information support for low carbon technology
- 2030s new mobility (ownership, personal mobility)
- 2040s city structure optimization of mobility

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

ICT Infrastructure for Traffic Improvement

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

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Network support for automobile

Recent advances in automotive electronics is to give better services using communication network

Many of services are related to social need and infrastructure

- Increase operational efficiency capacity of the transportation system
- Enhance personal mobility, convenience and comfort of the personal mobility.
- Improve the safety of transportation system
- Reduce energy consumption and environmental cost
- Enhance the economic productivity of individuals, organizations and social economy.

Automobile user service through network -1

- Travel and traffic management
  pre trip information, en route information, route guidance, travel information, incident management
- Public transportation management
  pre trip and en route information, preservation and personal arrangement
- Electronic payment
- Commercial vehicle operation
  commercial vehicle administration
- Emergency management
  emergency notification, personal security, emergency vehicle management, disaster response and evacuation

Automobile user service through network -2

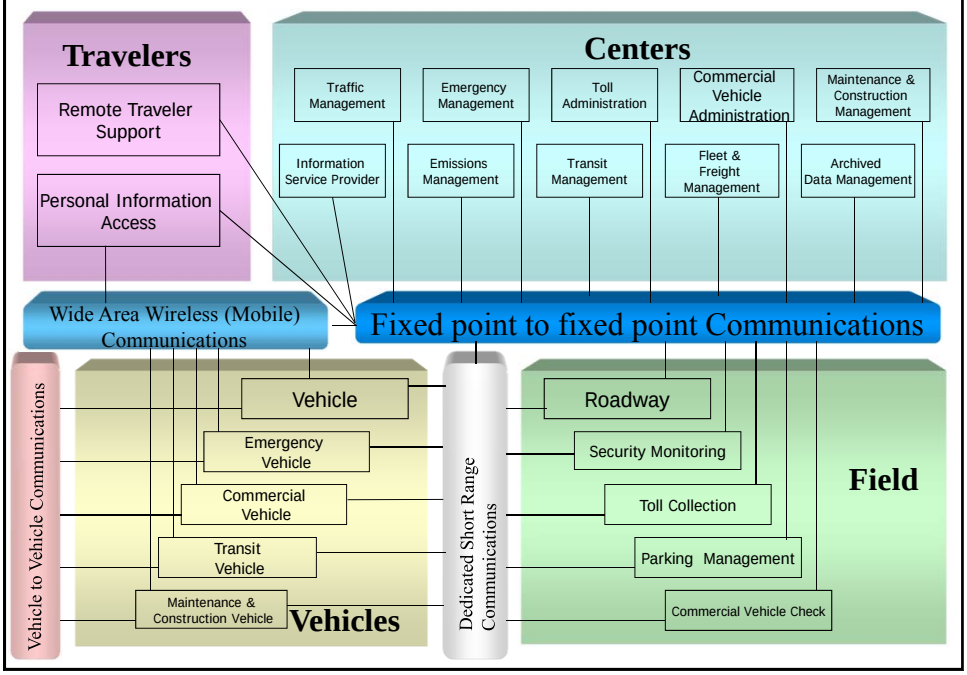
- Vehicle safety system
  Longitudinal and lateral collision avoidance, intersection collision avoidance, vision enhancement, safety readiness,
  Automated vehicle operation
- Information management
  Archived data
- Maintenance and construction management
  Maintenance of vehicle through remote monitering
  Software updating through network
  Coordination of multiple organization to schedule maintenance and construction service

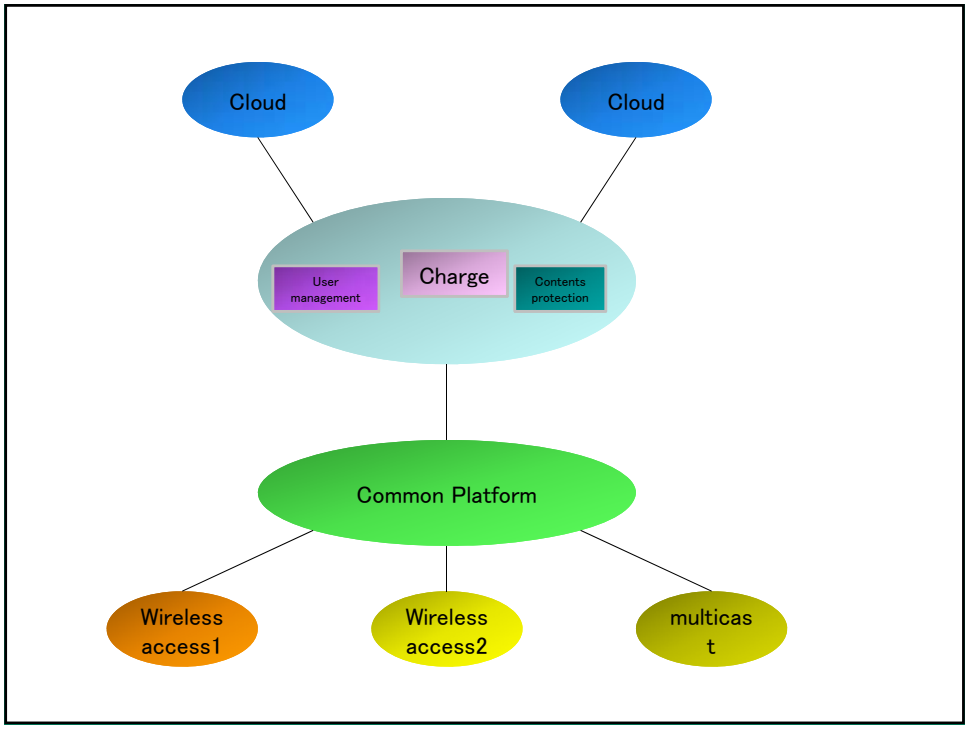
Requirements for software in automobile environment

- Performance improvement by electronics and network
  clean air, stability, safety, HMI, adaptation to infrastructure
- Adaptation to fast change in information and communication technology
  partial change of hardware, software update
- Reduction of complexity having potential danger of malfunction.
  small software unit, well tested software module
- Protection of the product from fault and malware
  fault free development and intensive test, proprietary interface

ITS Architecture

(ITS America1996)





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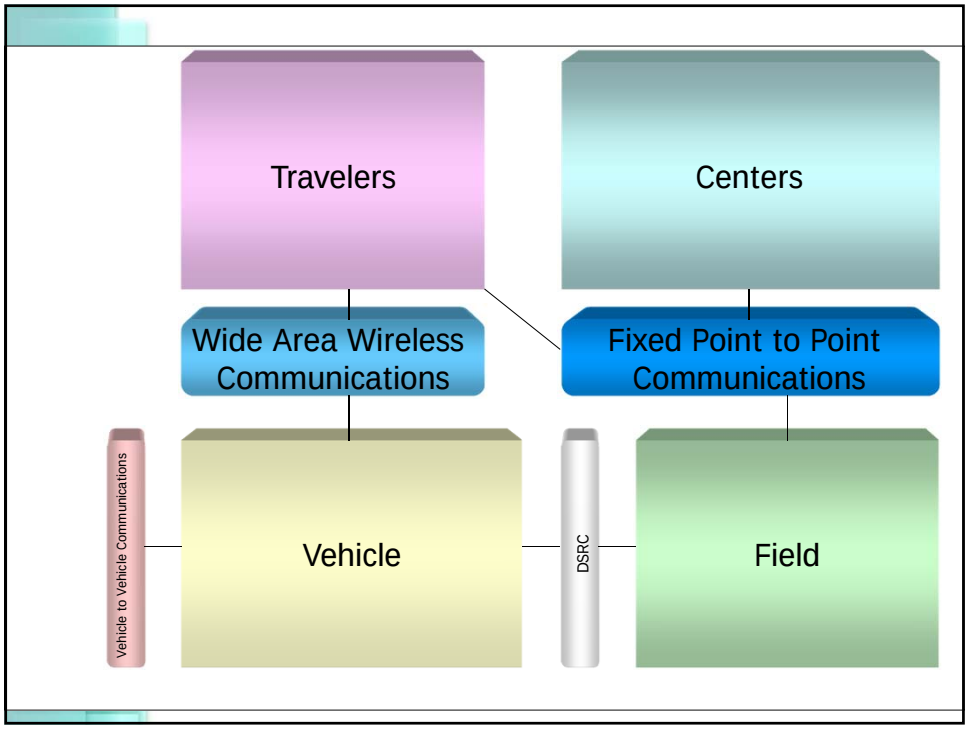
Two classes of vehicle communication

- ITS(Intelligent Transport System)
  Vehicle services using DSRC(short range dedicated communication)
  - probing,
  - fee collection,
  - intersection safety warning
- Tansport Telematics
  Vehicle services using cell phone service
  - emergency management
  - stolen vehicle responses
  - remote vehicle support
  - personal route guidance

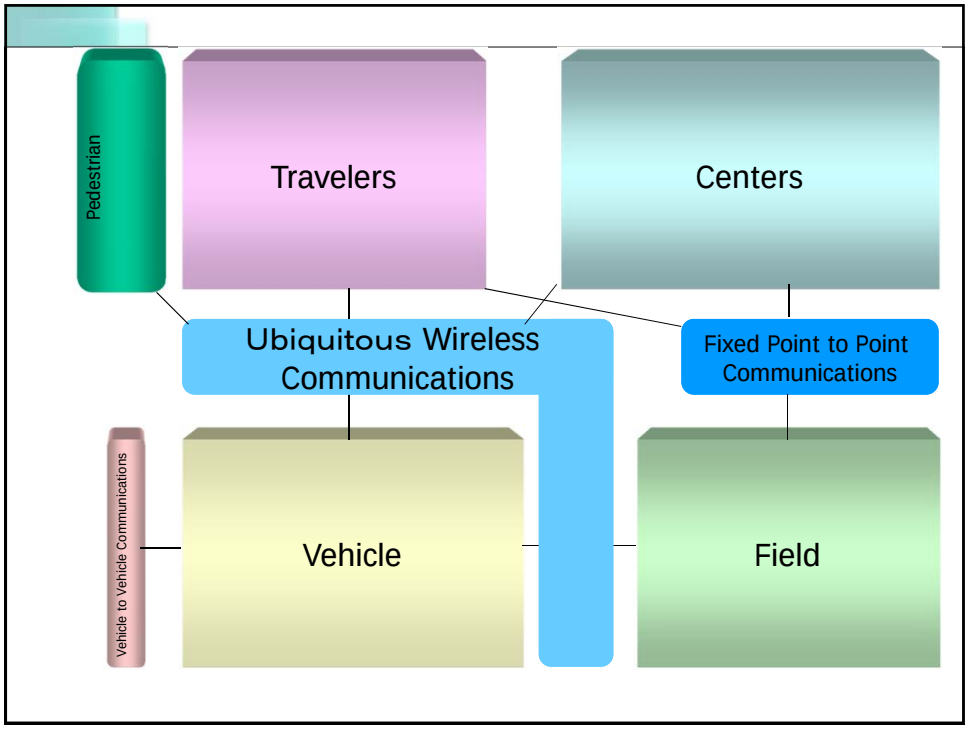


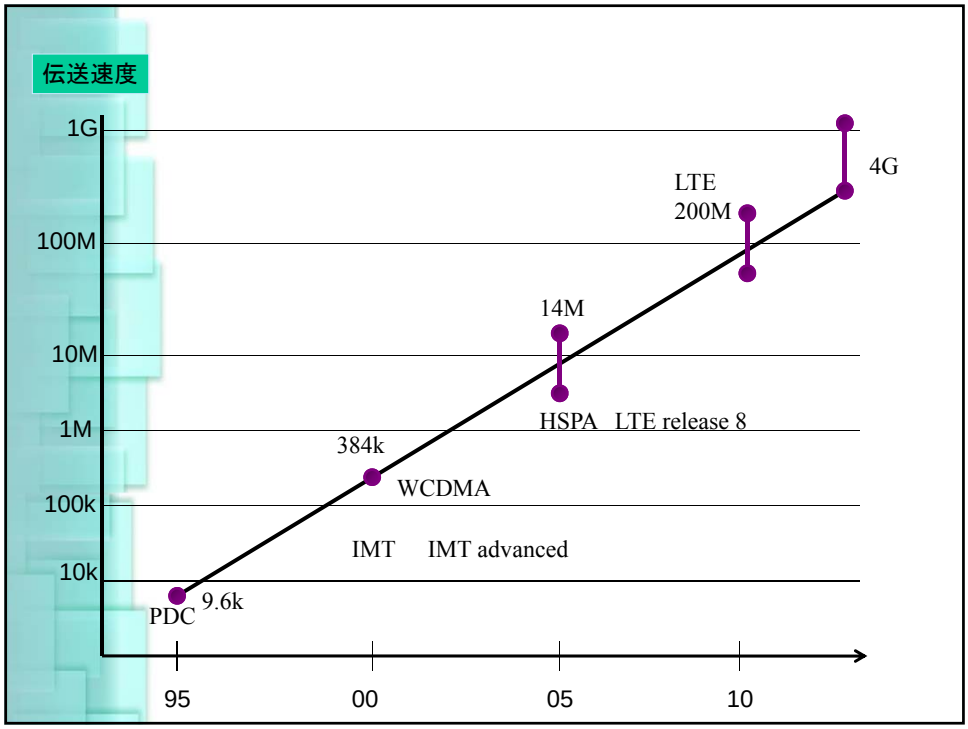
Requirement for vehicular communication

- Quick setup of communication when needed
- Communication capacity needed depending on situation
- Availability even in less populated area
- Stability for communication in shadowing condition
- Light weight equipments for vehicle human communication
- Global standardization to serve cross boarder market and trip

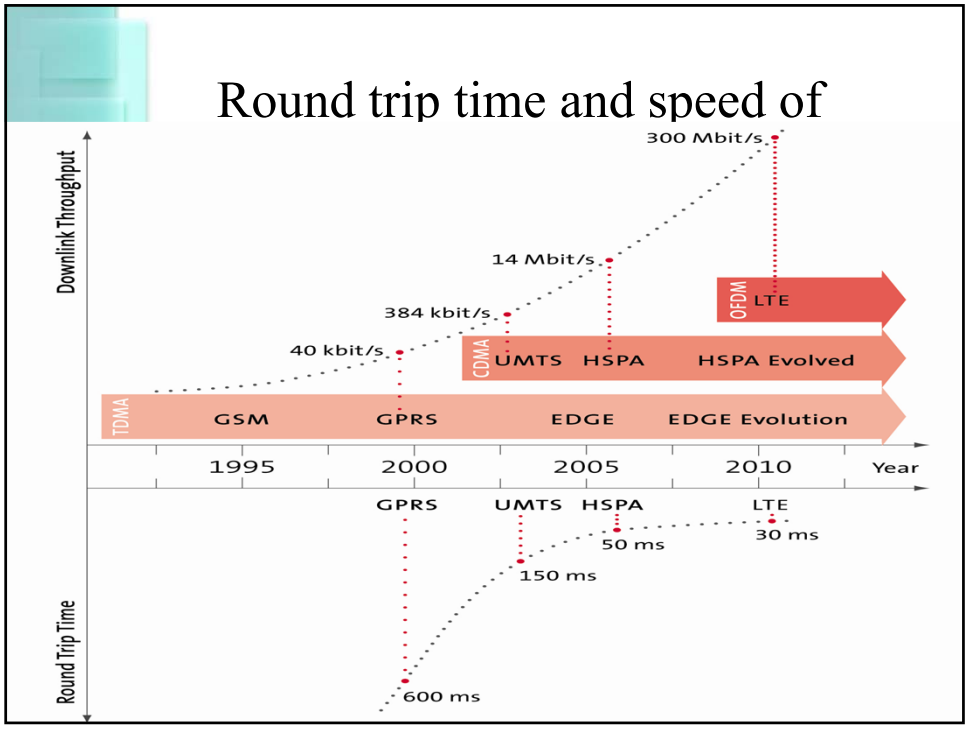
Cell Phone as the Forerunner for Vehicle Communication

- 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.
- 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 current Cell phone does not satisfy the requirement for ITS, appropriate design to satisfy requirement should be possible if new market is possible in future.

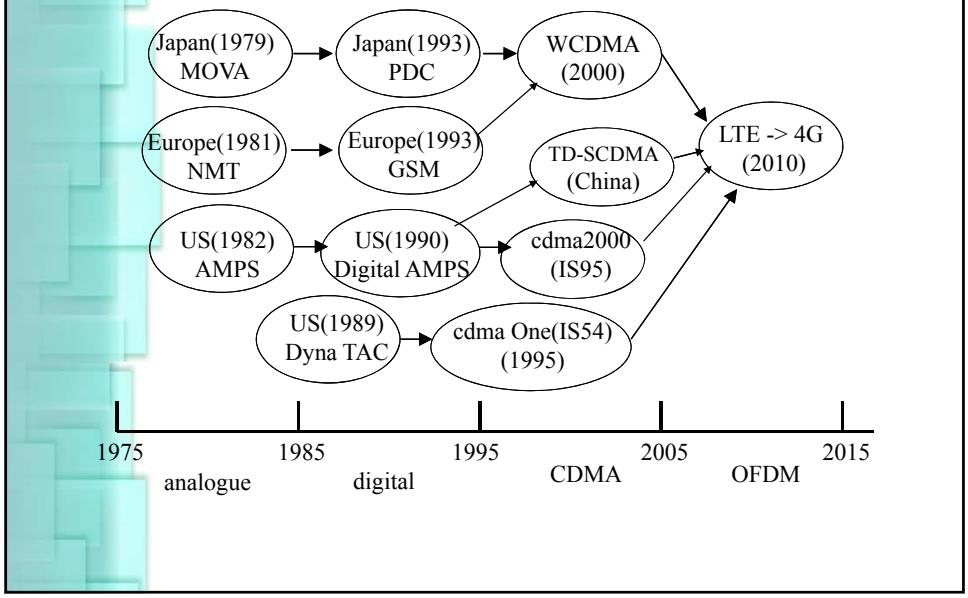

Pedestrian
Travelers
Centers
Ubiquitous Wireless Communications
Fixed Point to Point Communications
Vehicle to Vehicle Communications
Vehicle
Field


伝送速度
1G
100M
10M
1M
100k
10k
4G
LTE
200M
14M
HSPA
LTE release 8
384k
WCDMA
IMT
IMT advanced
PDC
9.6k
95
00
05
10

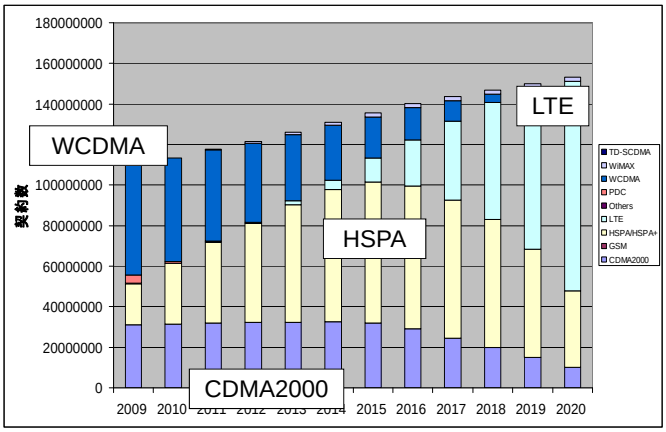
Round trip time and speed of



Cell Phone standards can be unified after the history

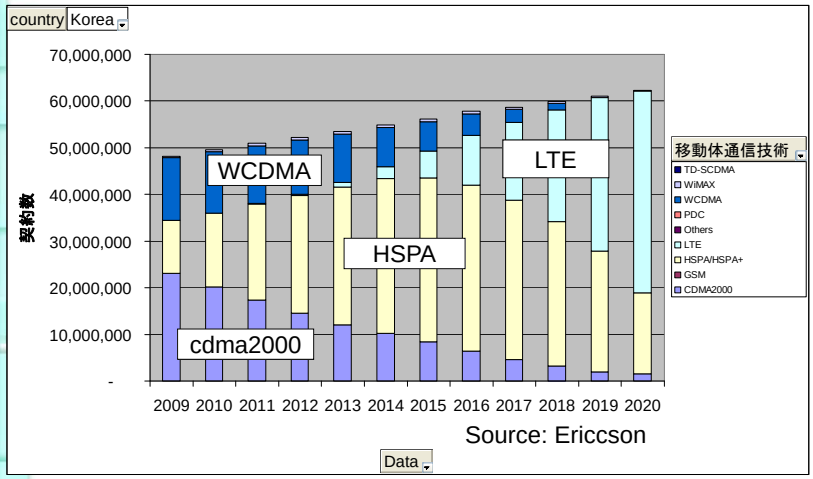


Prediction of LTE （Japan）



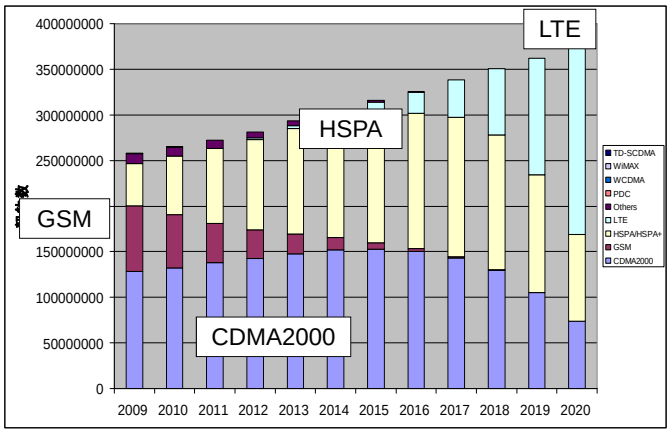
Source: Ericcson

Prediction of LTE （Korea）



Source: Ericcson

Prediction of LTE （US）



Source: Ericcson

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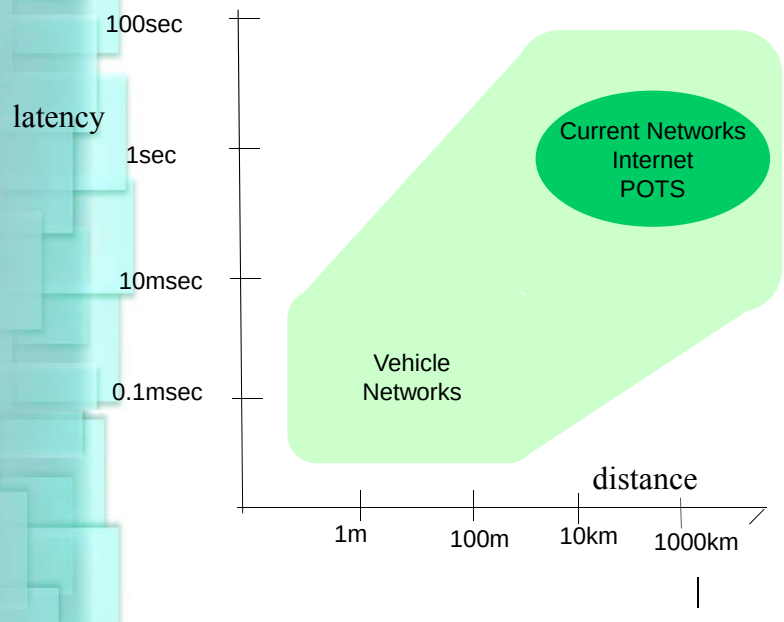
Broad Range of Requirements for Machine to Machine Communication

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, 20years, 100years

An Example of Performance Requirement for Vehicle Service



Communication performance requirement for

intersection safety warning

Latency for Setup	10msec
Distance of Communication	1m ～ 100m
Data Speed	100b/s ～ 10kb/s
Coverage	surrounding
Addressing	location
Error rate	10^{-5} ～ 10^{-3}
Life of technology	roadside 50 years
	vehicle 20 years

Communication performance requirement for

intersection collision avoidance

Latency for Setup	10msec
Distance of Communication	1m ～ 100m
Data Speed	100b/s ～ 10kb/s
Coverage	surrounding, linear
Addressing	location
Error rate	10^{-9} ～ 10^{-5}
Life of technology	roadside 50 years
	vehicle 20 years

Communication performance requirement for

mayday support (accident response)

Latency for Setup	1sec ～ 100sec
Distance of Communication	10km ～ 1000km
Data Speed	10kb/s ～ 1Mb/s
Coverage	plane (global :cross border)
Addressing	vehicle, machine
Error rate	10^{-5} ～ 10^{-3}
Life of technology	roadside 50 years
	vehicle 20 years

Requirement for Cellular Network

- 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.
- For safety application, always on service will be needed.
- Possible number of vehicles to be served by cellular network is also be a problem.
- To keep the cost low for safety application is to be studied including new protocol common with another M2M services.

Information Environment for Human

In everyday life, people are exposed in networked information environment.

- business and personal mail
- information support
- social networks
- entertainments
- shopping

These information is provided by Machine to Human framework.

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Taking advantage of flexibility of human operation, system can be changed or added frequently. Life time of one system can be short.

Many of services are provided in open environment.

Open platform can be adapted to many hardware in the environment hardware technology is stable and simple.

Stable hardware platform is provided by defact standard came from technical monopoly.

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Close ⇔Open

In computer world, before Intel, Microsoft based defact standard, many architecture coexisted and changed rapidly.

Open standards have been established, based on the defact standard.

If new technology comes in reality, it can support closed service.

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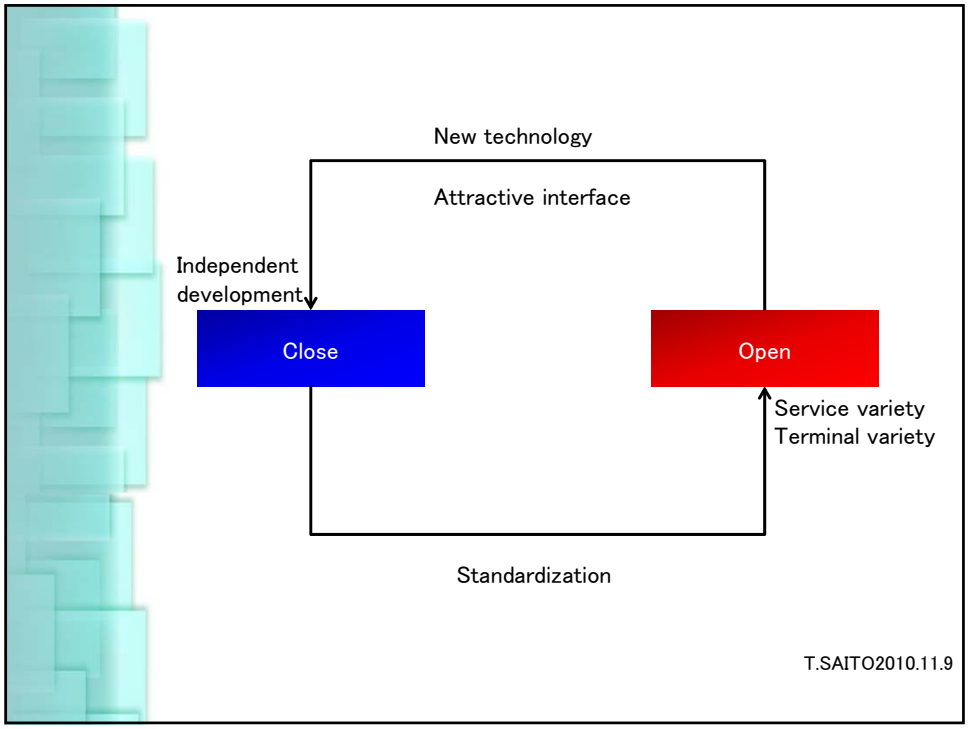
New technology
Attractive interface
Independent development
Close
Open
Service variety
Terminal variety
Standardization
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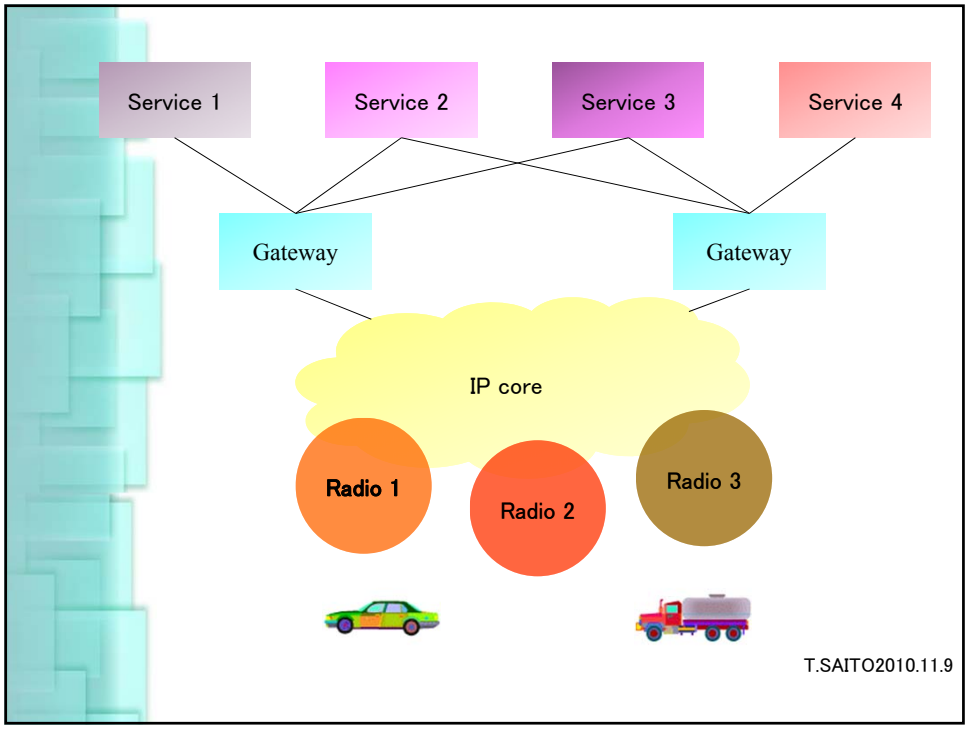
Service 1
Service 2
Service 3
Service 4
Gateway
Gateway
IP core
Radio 1
Radio 2
Radio 3
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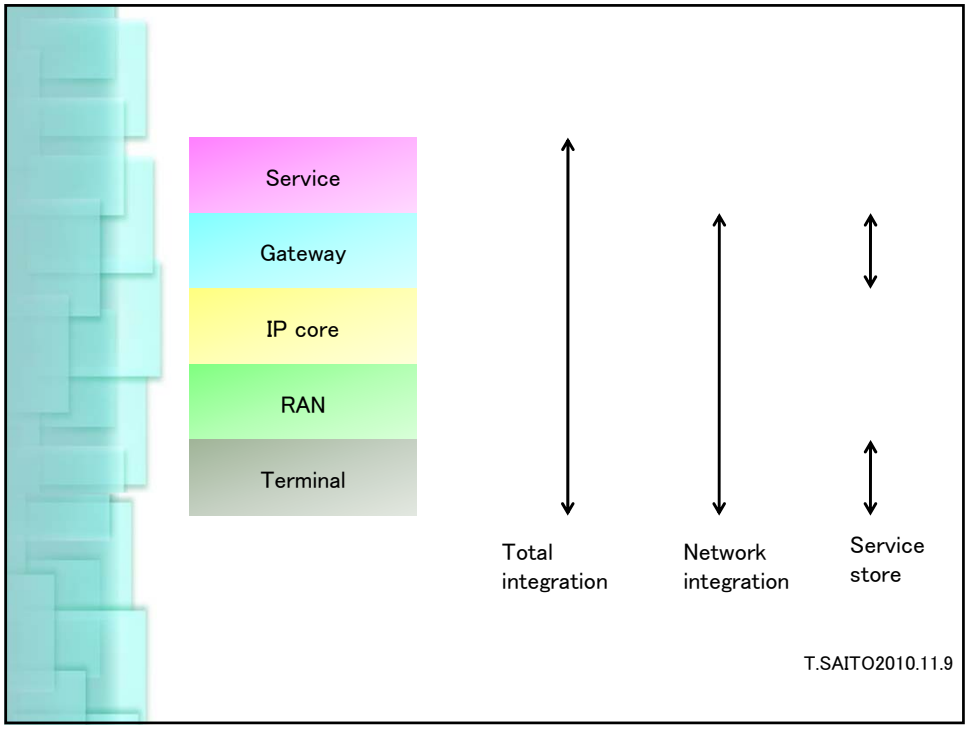

Information services for vehicles

Entertainment
Information support to drivers and passengers
Traffic management
Social network and probing
Remote maintenance
Ownership support
Commercial vehicle operation
Public transport operation
Emergency management
Vehicular safety

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Open services

Services to human in the vehicle.

Human can be adaptive to variations.

Human want to have environment common to his home and office.

The service can be provided through cellular mobile devices carried by drivers and passengers.

Many of vehicle data is difficult to access because difficulty of standardization of vehicle models.

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OEM services

A vehicle composed of many components.

Components changes model by model, and variety of model is broad.

Model of vehicle changes periodically and components are changed or replaced.

Support of vehicle including remote maintenance is only possible through the decision data of OEM.

Avoidance of Malware is essential to keep safety.

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Operation support

Commercial vehicle are supported by the schedule of service providers.

Public transportation is also managed by operators.

Emergency supports including e-call and stolen can tracking are responsibility of police.

Vehicular safety communication can be provided by control of government.

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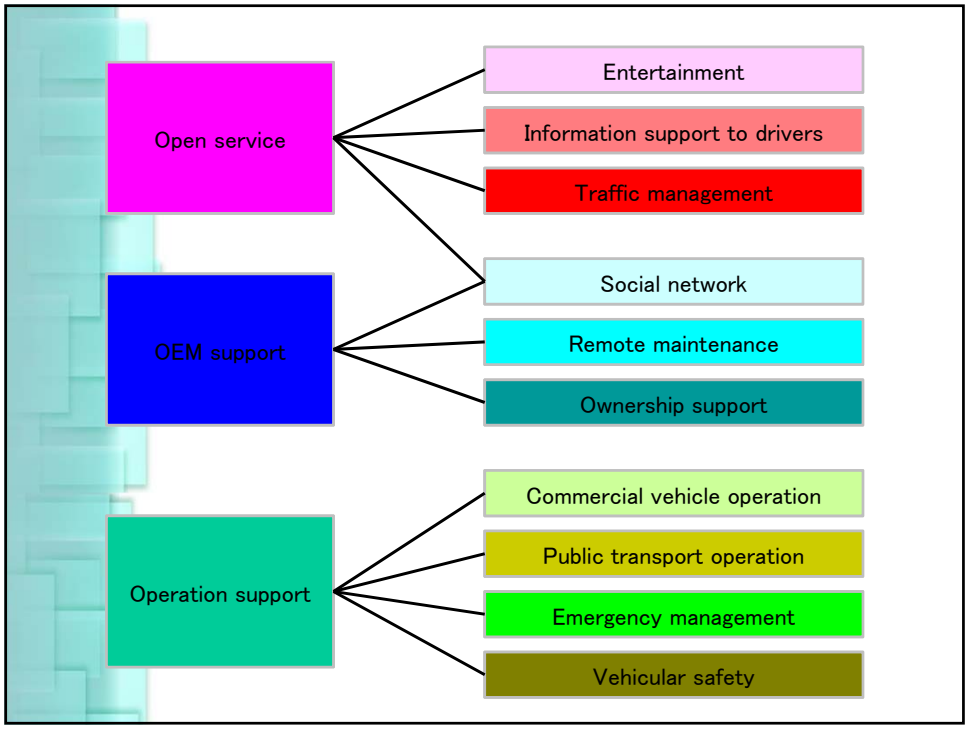

Automobile as a computer

- As functions supported by information increases, concept of automobile looked to be similar to computer
- Human interface similar to smart computer system became a fashion in automobile.
- Adaptation of equipment to traditional infrastructure and safety in environment of shared use of infrastructure is major difference of requirement.
- Life of product related to rapid change in technology is another difference.
- Adaptability to technology change by means of remote update of software can help the difference of life.
- Replacement of components and electronics to adapt technology change also important to cope with big change in technology.

Communication when standard are not established

- Different model of vehicle have different architecture and design.
- Rich variety of design is important in vehicle technology.
- Price of passenger vehicle range $10k-100k
- Vehicle users appreciate value of variety.
- Different vehicles have different functions.
- Vehicle OME service must take care of the variety.