Symposium on The Future Networked Car
(Geneva, Switzerland, 5 March 2015)

Security issues related to the future Networked Car

Koji Nakao
Distinguished Researcher,
Network Security Research Institute, NICT
Information Security Fellow, KDDI
Agenda

- Background
- Framework of ITS security for standards
- On going work for secure software remote update (ITU-T X.itssec-1 (draft))
- Utilization of light-weight crypto
- V2V Communication Verification Project in Japan
## Increase in Automotive Electronics

<table>
<thead>
<tr>
<th>50%</th>
<th>100</th>
<th>100 million</th>
<th>5</th>
<th>2miles</th>
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</thead>
<tbody>
<tr>
<td>Proportion of electronic components of car production costs</td>
<td>Number of ECUs in luxury models</td>
<td>Number of lines of car software</td>
<td>Number of networks in the car (average)</td>
<td>Length of cable in the car</td>
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</table>

### Software Development Volume

- Multimedia
- Audio
- Vehicle
- Body
- Airbag
- Assist
- Chassis
- HV
- Powertrain

### Software Development Cost

<table>
<thead>
<tr>
<th>Year</th>
<th>Multimedia</th>
<th>Audio</th>
<th>Vehicle</th>
<th>Body</th>
<th>Airbag</th>
<th>Assist</th>
<th>Chassis</th>
<th>HV</th>
<th>Powertrain</th>
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</tr>
</tbody>
</table>

ECU: Electronic Control Unit
Connected Vehicles

- Internet connection (LTE, 3G, Wi-Fi, Bluetooth …)
  - via customer’s smartphone, SIM embedded in the vehicle, etc.

- Autonomous car
  - Control engines and brakes based on the info from roadside infrastructure as well as car-mounted sensors, cameras, and radars

Sources: Cisco IBSG, 2011, based on data from U.S. Department of Transportation, iSupply, McKinsey & Company

1 Average of 1.5 GB/month/vehicle, 1 Petabyte = 1,048,576 GB
The Connected Car

100% Of cars will be connected by 2025

75% Of cars on the road will be autonomous by 2035

On-Board Diagnostics

Safety Sensors

Infotainment

360° Camera System

Seamless Connectivity with Mobile Devices

http://johndayautomotiveelectronics.com/top-five-technologies-enabling-the-connected-car/
More Attack Surfaces!

Unauthorized packets are sent
Malware created in car as communication gateway
Exposes OBU and starts sending many bad packets
Creates malware on the ADAS
Sends a super-packet
The car is destroyed

Framework of ITS standards (not authorized in ITU-T)
Architecture of a series of standards (General issues)

- Reference Architecture/Model
  - ITS Ref. Model

- Terminologies
  - Common Terms for ITS

- Service Models (def) and Requirements
  - V2V, V2I, V2N
  - Service Requirements

- Service/Protocol Specifications
  - e.g. Software Remote Update

- Mechanisms and Algorithms
  - e.g. Encryption, Message Processing
Architecture of a series of standards (Security issues)

- Reference Architecture/Model
  - ITS Ref. Model
- Terminologies
  - Common Terms for ITS
- Service Models (def) and Requirements
  - Security Guideline
  - Security Requirements
- Service/Protocol Specifications
  - e.g. Secure Software Remote Update (X.itssec-1)
- Mechanisms and Algorithms
  - e.g. Encryption, Mac, Authentication..
On going work for software remote update
(ITU-T X.itsssec-1 (draft) by SG 17)
Works related to Remote Update in other SDOs

**ISO TC204 24102-2**
- ITS TC204 24102 series focuses on ITS station management
- Part 2 (24102-2) discusses about remote maintenance of ITS-SCU (station communication unit)
- It does not include remote maintenance of devices on vehicle
- Provided by ETSI TC ITS below

**ETSI TC ITS**
- Provides 20 standards regarding ITS that include ITS infrastructure, communication protocol, etc.,
- Collaborating with EVITA, PRESERVE for a structured standardization
  - EVITA: an FP7 project to develop security mechanisms for on-board devices
  - PRESERVE: an incoming project of EVITA which aims to develop and experiment an HSM based V2X communication technology
- SG17 needs to survey activities in ETSI TC ITS regarding standardization of secure software update
Introduction of draft Rec. X.itssec-1

“Scope”

**Functionality of Head Unit**
- Status check of ECUs
- Log collection
- In-car diagnosis function

**Functionality of Server**
- Stored Data Definition
- Auth info
- Log Audit
- With considerations of privacy concerns

**Communication protocol**
- Between Car and Manufacturer / Garage
- Encryption
- Authentication

**Diagnosis of on-board devices**
- Status check of ECUs
- Log collection
- Verification of update module

- Aftermarket Communication Device
- Embedded Information Device
- Power Management Control ECU
- Seat Belt Control ECU
- Driving Support ECU
- Parking Assist ECU
- Skid Control ECU
- etc.,
1. ECU generates a digest of its SW with its own secret key and sends it to the head unit

2. Head unit verifies the digest

3. Head unit merges collected digest and resigns it with its own secret key, then sends it to the manufacturer center

4. The center determines an update program, signs it with own secret key, sends it to the head unit.

5. Head unit verifies the update program and transmits it to ECU

6. ECU applies the update program by itself

7. Again, ECU generates a digest, sign it and sends it to the head unit for verification

8. Head unit verifies the digest

9. Head unit resigns the digest with own secret key, and sends it to the center

10. The center determines whether SW update process is successful or not. After the process has done successfully, the center stores the update log into own DB.
Requirements for the secure software update

**Functions requirements to be provided**

- Remote diagnosis of software modules of on-board devices
- Digest based software verification at center
- Secure delivery and application of update modules
- Log audit at center

Apply digital signature or MAC mechanism using HSM

**Limitations inherent to ITS environment**

- Characteristics of ITS communication environment
  - High latency, low bandwidth, frequent disconnection, etc.
- Non-continuous operation of vehicles
  - Disconnections due to frequent stop and start of engines
  - Long durations with no connection (e.g., long summer vacation)
- Low computational power of ECU and HSM
Securty Considerations for Software Remote Update

Functionality of Head Unit
- Status check of ECUs
- Log collection

Communication protocol
- HTTPS with client auth
- TNC (RFC5792/5793)
- IPsec, VPN, etc.,

Functionality of Server
- Definition of Stored Data
  - Auth info
  - Log Audit
- With considerations of privacy concerns

Hardware Security Module (HSM)
- HSM as a trust anchor
  - HSM (EVITA)
  - TPM (TCG)
  - SHE (HIS)

Update Server and Log Repository at Car Manufacturer / Garage center

Secure Communication

Communication Head Unit

Embedded Information Device
- Power Management Control ECU
- Seat Belt Control ECU
- Driving Support ECU
- Parking Assist ECU
- Skid Control ECU
- etc.,
6. Basic model of remote software update
   1. Definition of components for secure software update in the ITS environment
      1. ECU
      2. Communication head unit
      3. Center server
   2. Basic mechanism

7. Threats and Risk Analysis

8. Functional requirements for the secure software update
   1. Remote diagnosis of software modules
   2. Digest based software verification
   3. Secure delivery and application of update modules
   4. Log auditing

9. Model and procedure of secure software update
   1. System model
   2. Data flow of remote software update

10. Functional specifications for components on the ITS environment
    1. In-car communication devices
    2. Communication head unit
    3. Center server

11. Practical use cases
Conclusions and Recommendations

- Introduced Secure Remote Update;
- It is under development in ITU-T SG 17 as a Recommendation X.itssec-1;
- The Recommendation should be a neutral content without introducing some specific methods;
- Collaboration with automotive industry is necessary including with EU and US;
- The goal of the Recommendation should be a practical reference/guide for implementing secure remote update for software in the vehicle.
Utilization of light-weight crypto
Much data to be protected(1)

Controller Area Network (CAN) Data

1 Adaptive Cruise Control
2 Electronic Brake System MK60 E
3 Sensor Cluster
4 Gateway Data Transmitter
5 Force Feedback Accelerator Pedal
6 Door Control Unit
7 Sunroof Control Unit
8 Reversible Seatbelt Pretensioner
9 Seat Control Unit
10 Brakes
11 Closing Velocity Sensor
12 Side Satellites
13 Upfront Sensor
14 Airbag Control Unit

http://www.aa1car.com/library/can_systems.htm
Much data to be protected (2)

V2X Communication Data

http://telematicswire.net/connected-cars-and-smart-homes-coherence-of-a-convergence-platform/
Lightweight Cryptography

“Cryptography tailored for implementation in constrained environments” [ISO/IEC 29192-1]

- **Constraints:** chip area, energy consumption, power, memory, communication bandwidth, execution time, etc.
- **Applications:** RFID tags, sensors, health-care/medical devices, low-energy applications, low-latency applications, ...

**Suitable for Internet of Things!**
Lightweight Cryptography

R&D
  - European Network of Excellence for Cryptology funded within ICT Programme of the European Commission's FP6, FP7
- Japan CRYPTREC (2013-)

Standardization
- ISO/IEC 29192
  - Lightweight Cryptography, in ISO/IEC JTC SC27 WG2 since 2009
Why Lightweight Cryptography for Vehicles? (1)

- A modern vehicle contains 50 to 100 or more electronic control units (ECUs).
  - collection of embedded constrained devices
- CAN bus data field is (only) 32 bits.

http://www.digikey.jp/ja/articles/techzone/2014/jul/what-engineers-need-to-know-when-selecting-an-automotive-qualified-mcu-for-vehicle-applications
## Why Lightweight Cryptography for Vehicles? (2)

<table>
<thead>
<tr>
<th>Properties</th>
<th>AES</th>
<th>Lightweight block ciphers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block Size</td>
<td>128 bits</td>
<td>64 bits</td>
</tr>
<tr>
<td>Key Size</td>
<td>128/192/256 bits</td>
<td>80-128 bits</td>
</tr>
<tr>
<td>Key Schedule</td>
<td>Light (Simple)</td>
<td></td>
</tr>
<tr>
<td>S-box</td>
<td>8 x 8</td>
<td>4 x 4</td>
</tr>
</tbody>
</table>

### Hardware Implementation

| Gate Size (ASIC)           | 3-10 Kgate               | < 3 Kgate                 |
| latency                    | < 20ns within 10Kgates   |                           |

### Software Implementation (on microcontrollers)

| ROM (Enc+Dec)              | 1KB                      | < 200B                    |
Why Lightweight Cryptography for Vehicles? (3)

Chip Area (Gate Size) [Kgate]

Lightweight block ciphers

Small (=low power)

Low Latency

- Real-time response is crucial in Advanced Driver Assistance Systems (ADAS).
- AES can’t achieve encryption in dozens of nano-seconds within dozens of kgates.
Conclusions and Recommendations

- Introduced **lightweight cryptography**
- Suitable for **constrained devices**, the connected cars and ITS security.
- Some lightweight algorithms are mature and standardized in ISO/IEC.
- It’s high time to standardize **practical standards for connected cars and ITS security** in ITU-T.
- Collaboration with automotive industry is necessary.
ICT for Next Generation ITS
—MIC ITS Project Result Presentation—

V2V Communication Verification Project

<Subcontracted investigation of communication technologies toward the establishment of next-generation ITS>

Toyota Tsusho Corporation
Objective of V2V communication

**V2V communication** is used to help maintain a smooth traffic flow by transmitting information about an approaching emergency vehicle to other vehicles in the neighborhood.

**V2V communication** is used to prevent corner-to-corner collisions at intersections with poor visibility.

**V2X communication** is used to prevent accidents caused by pedestrians (persons) dashing out in front of vehicles (the next step).
Identified services expected to be commercialized in early stage

Identification of Services

- Support for preventing collisions during right turns
- Support for preventing accidents during left turns
- Support for preventing corner-to-corner collisions at intersections with poor visibility
- Support for recognizing approaching emergency vehicles

System definition, Result evaluation

Message Set Examination

Viewpoint of identification

- Previous examination
- Target market
- Competing service
- Similar services overseas

Collision prevention support

Support in recognizing vehicles in the vicinity

Identified services expected to be commercialized in early stage.
Security Evaluation(1)

[Security evaluation scope]

<table>
<thead>
<tr>
<th>Phase</th>
<th>Startup phase</th>
<th>Popularization phase</th>
<th>Expansion phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trends in safe driving systems</td>
<td>Start of safe driving assistance systems based on V2V communication</td>
<td>Start of safe driving assistance systems based on V2I communication</td>
<td>Start of safe driving assistance systems based on V2X communication</td>
</tr>
</tbody>
</table>
| Security items to be considered in each phase | • Security method for V2V communication  
• Security key operation management method | • Security method for V2I communication  
• Framework for maintaining security  
• Security update method  
• Abnormality detection method | • Security method for V2X communication |

[Investigation Flow]

700MHz band safe driving assistance systems  
Security requirement (MIC 2014)

Security method for V2V communication
• Evaluated security methods.  
• Performance requirement check

Security key operation management method
• Evaluated operational procedure  
  ✓ Company registration  
  ✓ Security key issuance  
  ✓ Security key storage

Test 1

Test 2

Overall Verification
[Test 1] Security method for V2V communication

This process checks whether an in-vehicle system can send messages without any problem while also receiving messages from other in-vehicle systems in a simulated environment in which many vehicles are present.

[Test 2] Security operation management method

Evaluated operation management methods and carried out verification that assumed an actual operation.

*PKI: Public Key Infrastructure
Overall Verification
– Test Description

Test course (simulated street at JARI)

Public road (YRP: Yokosuka City)
Overall Verification – Test Result

[Security functions verification]
Human Machine Interface (HMI) example  Provided by Pioneer Corp.

(Left) Identified as an emergency vehicle
(Right) Fake emergency vehicle, which is originating the message that imitate an emergency vehicle, is identified as a general vehicle by the security functions.

- Realized V2V communication by the in-vehicle system that implements the security functions.
- Identified the emergency vehicle by the security functions.
Examination of V2P Communication Systems (near future Targets)

**Priority targets**

**Who:** Seniors (65 years or older), children (12 years or younger), and bicyclists

**Where:** Intersections on residential streets and single-lane roads with poor visibility

**How:** Crossing outside crosswalks (during right/left turn in the case of bicyclists)

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**Accident example collection and cause analysis**

**Case 1: Collision with cross traffic in intersection (seniors/children, bicyclists)**

→ Accidents that occur in narrow intersections without traffic lights in residential areas due to poor visibility

**Case 2: Pedestrian crossing right in front of or behind a vehicle on single-lane roads with poor visibility (seniors/children)**

→ Accidents that occur when a pedestrian (or bicyclist) dashes out from between parked cars or cars stopped due to traffic congestion in order to cross a two-lane road without a crosswalk

**Case 3: Pedestrian dashing out on a single-lane road with poor visibility (children, pedestrians)**

→ Accidents that occur when a child (pedestrian) dashes out of a house, store, or vacant lot without checking for safety

**Case 4: Turning right or left on a single-lane road without a dedicated bike lane (bicyclists)**

→ Accidents that occur when a bicyclist tries to turn right (left) without checking for safety

*Includes accidents that occur when a bicyclist swerves toward the middle of the road to avoid a parked car.*
Summary

Standardization of Recommendation X.itssec-1 (Secure Remote Update)

- Need to collaborate with SDOs (ISO: TC204, ETSI: ETSI TC ITS Working Group Security (WG5)) and EVITA, PRESERVE. TCG...
- This Recommendation should be a neutral content without introducing some specific methods for providing a practical reference/guide for implementing secure remote update for software in the vehicle.

Light-Weight Encryption for ITS

- Light-Weight is suitable for constrained devices, the connected cars and ITS security.
- It’s high time to standardize practical standards for connected cars and ITS security in ITU-T.

At the next SG17 meeting in April 2015, framework of standards for ITS will be discussed in connection with the work in SG 16.