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Cooperative Device Cloud – Provisioning Embedded Devices in Ubiquitous Environments
Context/Motivation
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IoT Resource Management Challenge

**lack of** on-demand, rapid provisioning, resource sharing, Pay as you Go, ...
Context/Motivation
Goal: Cloud goes IoT
Use Case: E-Health

Share the data sources (i.e. medical devices)

Patient

Hospital/Emergency

Telemedicine

Home Doctor

Multi Stakeholder Treatment Process
Architecture – Principles of Sharing

Contribute

Resource Pool

Consume

DN

AN

DN

DN

DN
Architecture – Principles of Sharing

Device Owner

Device Operator

Resource Pool

Device Integrator

Device Consumer

Device Target

Contribute
Agenda

Architecture

Data Model

Interaction Model

Communication Model

M2M

Application Integration
Data Model – Device State

Device Directory

Device Instance

DeviceInstanceState:
- CategoryStates:
  - {1, Consumer Bound}
  - {2, Idle}

Represented by

Device Lock
DeviceCategory = 1

Device Lock
DeviceCategory = 2

Attached to

Device Lock
DeviceCategory = 2

Defined by

Device Type
CategorySets:
- {1, 1, Display}
- {2, -1, Webcam}

Offers

Device Category Display
Device Category Webcam

Domain B

Device Directory
1. What is it?
2. Who owns / operates it?
3. Do I need it?
4. Yes -> request integration from operator
4. No -> offer integration to operator
5. negotiate
6. Issue device access token (Device Lock)
7. How to handle / integrate it?
Agenda

Architecture

Data Model

Interaction Model

Communication Model M2M

Application Integration
Communication Model – M2M

- Identify
- Attach
- Discover
- Refine

Runtime Composition
Communication Model – M2M

- Identify
  - Driver Service
  - Device Service
- Attach
  - GetVal(); SetVal(...);
- Discover
  - Discovery Record
- Refine
  - Device Category

Concepts:
- Ӱ����ϭϯ
- ԱԵՍԶԸՔ
- ՔԷՏՄՆԵՓՅՈՒ

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Agenda

Data Model

Interaction Model

Communication Model

Application Integration

Architecture
Application Integration

- Consumer Profile
- Entry 1: Device Category Bloodpressure
- Entry 2: Device Category ECG
- Entry ..: Device Category ...
- State
- Guard Condition
- Module Paths
- Path 1: Input Module → Transformation Module (x73) → Output Module
- Device Cloud Middleware
- Platform Modules
- Device Cloud
- Applications

- M2M
- Device Directory
Thank you for your attention!

QUESTIONS?
• SotA - Sensor-Cloud Integration
SotA: Sensor-Cloud Integration
Sensor-Virtualization fits well for many applications, but ...  
• involves intermediary actors (*privacy*, *trust*, *delay*)  
• how to model interest / need for a resource. How to establish dynamic bindings? (*mobile sensors*, *mobile users*)
SotA vs. Device Cloud

Sharing virtual representations
• Sensor-Virtualization
• EHR-Clouds
• M2M Clouds
• ...

Sharing physical things
• Car Sharing
• Sharing Economy
• Cooperative Device Cloud
Backup

• Security
Security - Basics

Interaction

Access / Modification

Device Directory
Device Representation

Resource Server
Authorization Server

Device Consumer

Consumer Operator

Device Owner

Consumer Operator

Request

Resource Pool

Protected Resources

Device Directory
User Directory

Grant
Security – Authentication

- Domain Operator
- User Directory
- Local Device Directory

- Consumer Operator
- Consumer
- AN

- Root Domain Operator
- Global Device Directory
- User Directory

- Local Device Directory
- User Directory

- Consumer Operator
- Consumer
- AN

- Aggregator

- Consumer Operator
- Consumer
- AN

- Aggregator
Security – Authorization

Device Directory

Access Control Matrix
- Read-Only
- Read-Write
- Append
- Control
- (Create)
- Delete

Basic Properties
- EntityType
- EntityID
- EntityDomain
- EntityVersion
- PrivateEntity
- EntityOwner
- EntityOperator
- PermissionSet

Device Instance
DeviceInstanceState:
- CategoryStates:
  - {1, Consumer Bound}
  - {2, Idle}

PublicKey
PrivateKey

Basic Properties
Device Lock
DeviceCategory = 1
LockingEntity=...
Aggregator=...
Security – Device Access Token

Device Access Token
- DeviceID
- LockID
- Issuer
- Validity
- CategorySet
- OperatorManaged
- OperatorToken
- PublicKey
- AttachedToken
Security - Issues

• Degree of confidentiality and integrity limited by device communication protocols
• Authenticity of devices
• Compromised Aggregator devices
Backup

- Decision Policies
Decision Policies

• Simple, state based decision making
  • Sufficient? -> handovers required? -> E-Health use case
• Handover-Types:
  • Aggregator Handover: only the Aggregator is changed
Decision Policies

• Handover-Types:
  • Aggregator Handover: only the Aggregator is changed
  • Consumer Handover: both, the Aggregator and the Consumer are changed
Decision Policies

• Device Cloud decision making is related to problem of pre-emptive scheduling

Scheduler has to compute priority given contextual data:
• Price
• Proximity of D to A and B
• Aggregator capabilities (rate regarding mobility, privacy, available resources)
• Device Target (unchanged may take precedence)
• Consumer priority (static)

Benefit of Device Owner