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# u2

# uID Architecture 2.0

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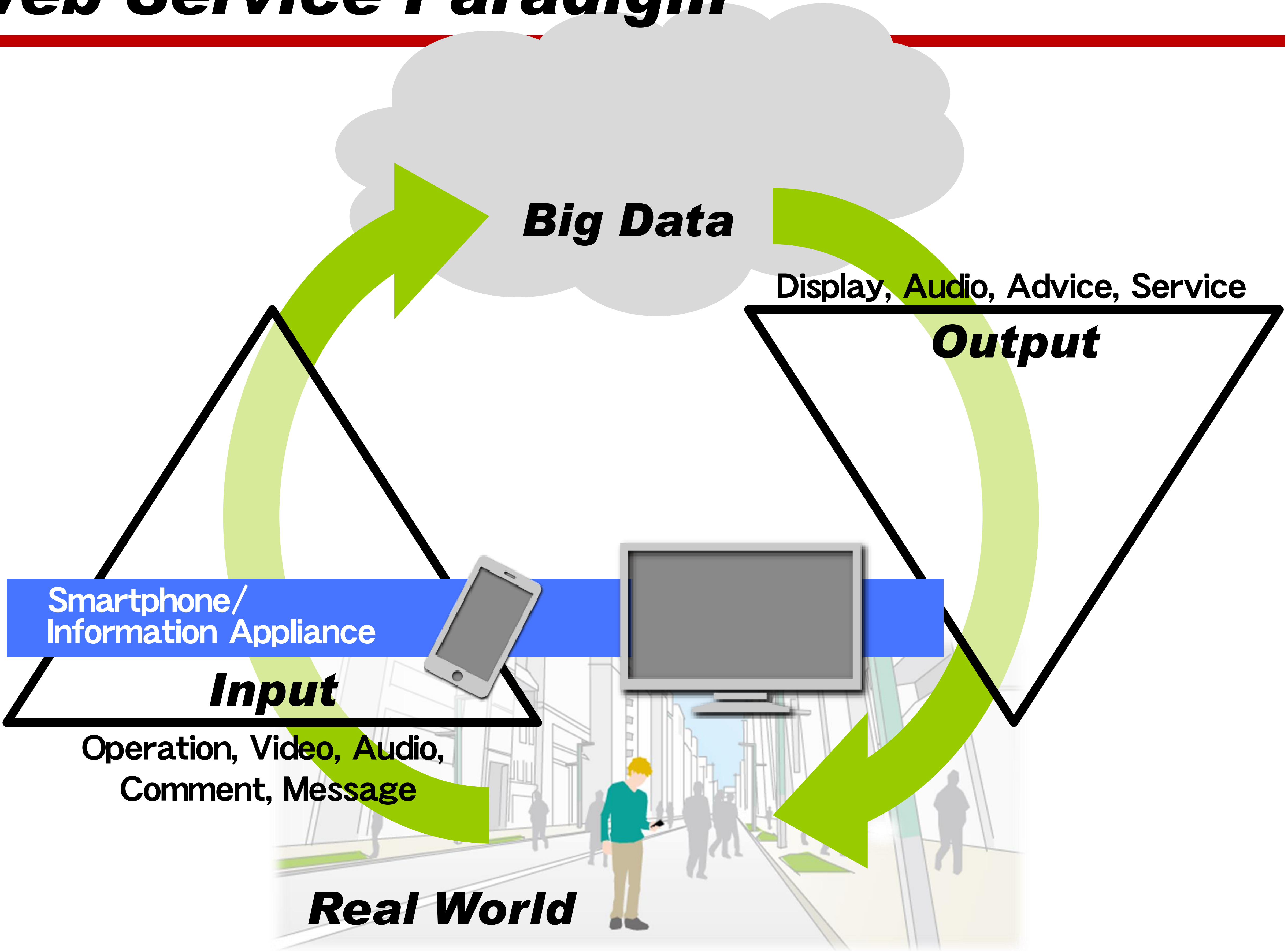
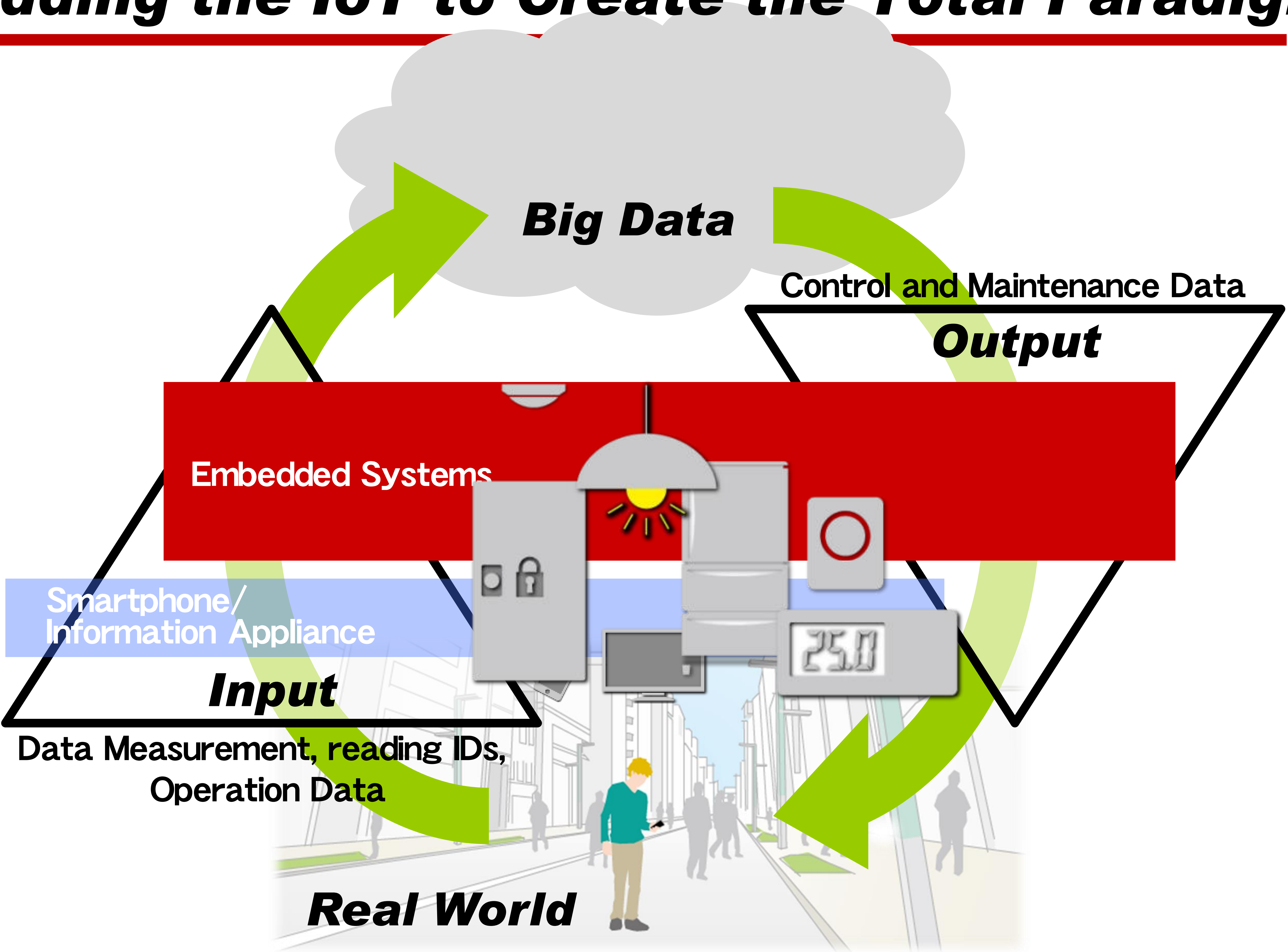
Chair, T-Engine Forum/uID Center

# ①
# The IoT Model

# Web Service Paradigm



# Adding the IoT to Create the Total Paradigm



Big Data

Control and Maintenance Data

Output

Embedded Systems

Smartphone/
Information Appliance

Input

Data Measurement, reading IDs,
Operation Data

Real World

# Input from the Real World as Big Data

Data from embedded sensor nodes

Operation data from embedded devices

Smartphone-based operation, video, photo, audio, comment and messages

↓

These are collected and assembled over the network into Big Data

# ***Output to the Real World using the Big Data***

***Efficient control of devices by analyzing Big Data***

***Fault prediction by analyzing Big Data***

↓

***Improved maintenance and operation efficiency***

***Provide advice and services by using display and audio to human users***

# ①
uID Architecture

# The Essence of “Ubiquitous Computing”

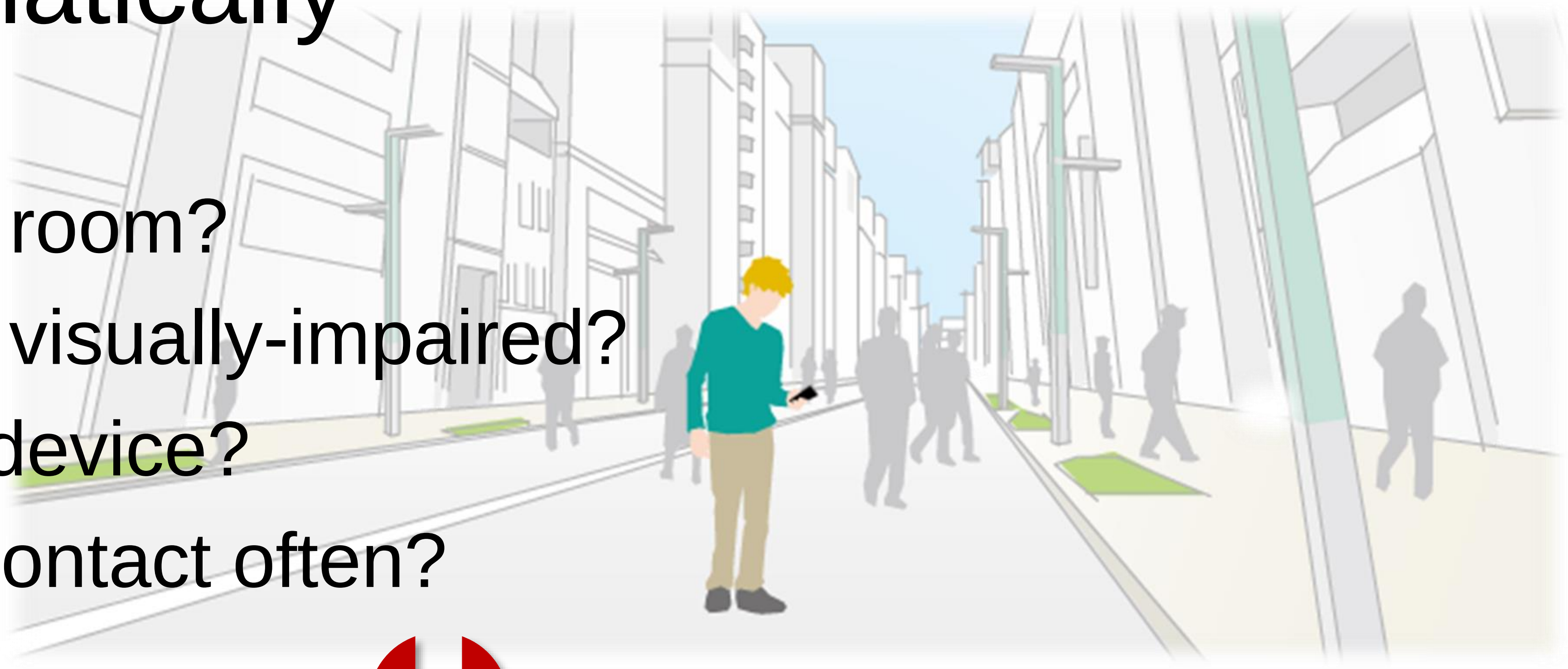
***Understanding of the situation / context of our living environment***

- Location and spatial information of objects and people
- Attributes of objects and people
- Various sensor values

***“Context Awareness”***

# What is Context-Awareness?

- Computer recognizing the status of the real world automatically
  - What is this?
  - Who is in this room?
  - Is this person visually-impaired?
  - Where is the device?
  - Who do you contact often?



↓

- At the root of recognition is identification ＝ IDentification

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# ***Assigning Identification Numbers to All which we want to recognize***

***The world consists of tangible objects and locations, but human activities in the world also involve notions or concepts***

↓

***We assign numbers to such abstract concept as well***

- E.g., a corporation, a lot, etc.

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# The Identification Number *is* ‘ucode’

### 128-bit ucode

- Can be unique to an object, location, or virtual object in an open and universal network
- A unique identification number in this world

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# ***Semantics externalized in the network***

***Note) Please do not confuse this with "Network externality" as in Economics***

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# *Merits of Externalizing the Semantics in the network*

- Necessary resolution for application
  - An address can specify a building, but it can even specify a particular shelf within an office of the building if necessary
- Freedom for an application provider to issue an ID as necessary
  - It is possible to issue an ID on the spot when it becomes necessary
- Openness that allows ID to be used by anyone, not restricted to the issuer
  - Nevertheless, It can be declared private so that others can only tell that it has been issued

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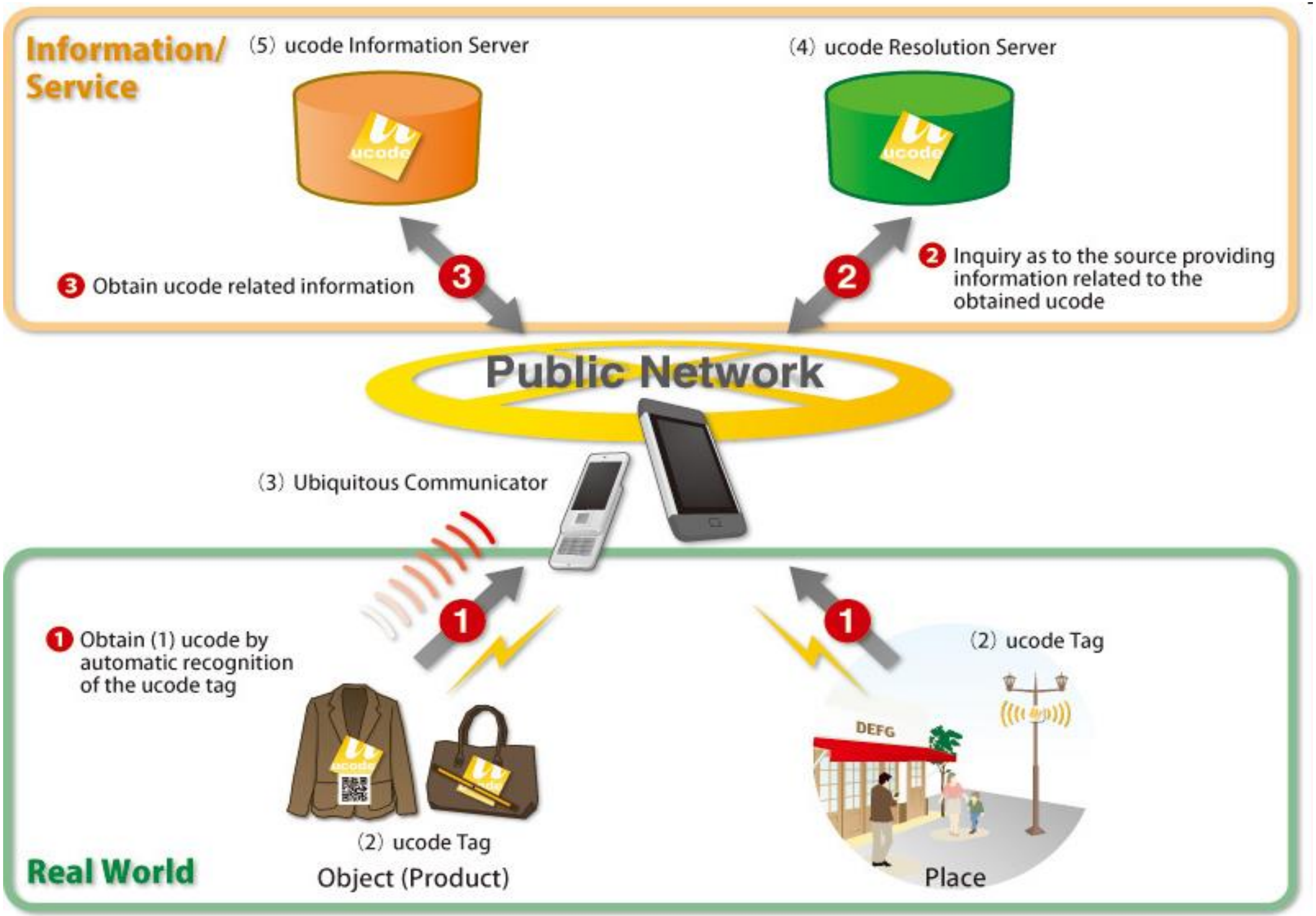
# Principle of Ubiquitous ID Architecture


Information/ Service
(5) ucode Information Server
(4) ucode Resolution Server
ucode
ucode
3
❸ Obtain ucode related information
2
❷ Inquiry as to the source providing information related to the obtained ucode
Public Network
(3) Ubiquitous Communicator
1
1
❶ Obtain (1) ucode by automatic recognition of the ucode tag
(2) ucode Tag
ucode
DEFG
(2) ucode Tag
Object (Product)
Place
Real World

# ②
# Why a Number?

# Why a “number” instead of a “name”?

- A “number” is a natural form for computers to handle
  - People are not good at handling numbers with many digits, and so use names instead
- A “number” can be used for unique identification
  - There are examples of different objects that share the same “name”
  - A “name” can not identify an instance of such similar objects
  - A proper name, when translated into foreign language, causes

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# Why a “number” and not a “name”?

- A “number” can be issued without special authority, as long as uniqueness is assured
  - When a “name” is used to identify something, we need to assign an “authority” to a party who can give such a “name”
  - When there are many things that are appropriate for a given “name”, who decides to give the name to a particular instance of them?
  - Can such a naming be agreed upon by the rest of the world?
- Full-featured management structure is not needed to assure uniqueness
  - Hierarchical naming such as URL and postal address reflects a particular management hierarchy, and if something is moved to a new hierarchy, a renaming has to occur, and thus perpetual identification is not assured

# Social Significance of ucode

“Public Property” in the age of Open Data

The importance of assuring uniqueness only and having no meaning in itself

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# *The Importance of Global Uniqueness*

- The world is moving toward "open" systems
  - E.g., Open data, open government, …
  - The IoT (Internet of Things) can also be considered a huge open system
- In open systems, common rules are crucial for interoperability among data, services, etc.
  - E.g., Controlling KADENs (electronic appliances) in a smart house
    → Kadens in a house usually come from many manufacturers: we need globally unique identifiers for specifying each kaden

⇩

- "ucode" as the lingua franca for specifying objects and notions uniquely among systems

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# As a future foundation for metadata resilience

***The persistence of IDs are crucial to assure the resilience of network of metadata of our society***

- An identifier that belongs to a particular organizational domain, such as vendor model serial number, should be carried over by a more public database when the original issuer ceases to exist

↓

- To handle such merging of databases, an identifier system that has built-in semantics of a particular domain is not desirable

# Recommendations Based on ucode Have Been Consented at ITU (International Telecommunication Union)

- ITU-T F.771 (2008)
  Definition of application requirements
- ITU-T H.621 (2008)
  System architecture
- ITU-T H.642.1 (2012)
  ID system architecture
- ITU-T H.642.2 (2012)
  Process of ID registration and management
- ITU-T H.642.3 (2012)
  Protocol for ID interpretation

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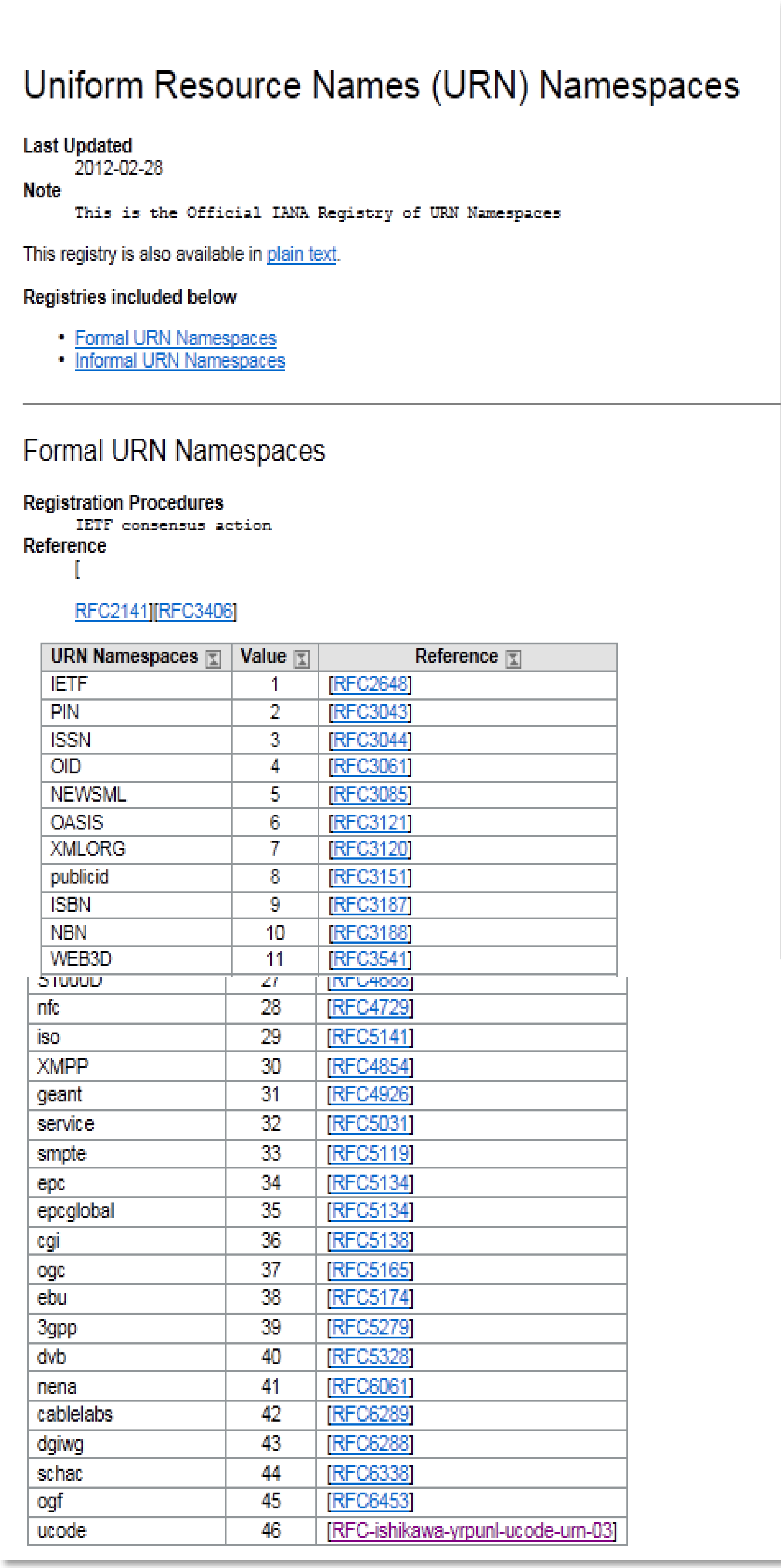
# International Standardization at IETF

- RFC 6588
  “A URN Namespace for ucode”
  - urn:ucode:_0123456789ABCDEF0123456789ABCDEF
    Representation above is standardized
- ucode can be used anywhere URI is used.
  - NFC (Near Field Communication) NDEF form
  - RDF (Resource Description Format) ID form



## Uniform Resource Names (URN) Namespaces

**Last Updated**
2012-02-28
**Note**
This is the Official IANA Registry of URN Namespaces

This registry is also available in plain text.

**Registries included below**

- Formal URN Namespaces
- Informal URN Namespaces

### Formal URN Namespaces

**Registration Procedures**
IETF consensus action
**Reference**
[
RFC2141][RFC3406]

| URN Namespaces | Value | Reference |
|---|---|---|
| IETF | 1 | [RFC2648] |
| PIN | 2 | [RFC3043] |
| ISSN | 3 | [RFC3044] |
| OID | 4 | [RFC3061] |
| NEWSML | 5 | [RFC3085] |
| OASIS | 6 | [RFC3121] |
| XMLORG | 7 | [RFC3120] |
| publicid | 8 | [RFC3151] |
| ISBN | 9 | [RFC3187] |
| NBN | 10 | [RFC3188] |
| WEB3D | 11 | [RFC3541] |
| S1000D | 27 | [RFC4688] |
| nfc | 28 | [RFC4729] |
| iso | 29 | [RFC5141] |
| XMPP | 30 | [RFC4854] |
| geant | 31 | [RFC4926] |
| service | 32 | [RFC5031] |
| smpte | 33 | [RFC5119] |
| epc | 34 | [RFC5134] |
| epcglobal | 35 | [RFC5134] |
| cgi | 36 | [RFC5138] |
| ogc | 37 | [RFC5165] |
| ebu | 38 | [RFC5174] |
| 3gpp | 39 | [RFC5279] |
| dvb | 40 | [RFC5328] |
| nena | 41 | [RFC6061] |
| cablelabs | 42 | [RFC6289] |
| dgiwg | 43 | [RFC6288] |
| schac | 44 | [RFC6338] |
| ogf | 45 | [RFC6453] |
| ucode | 46 | [RFC-ishikawa-yrpunl-ucode-urn-03] |

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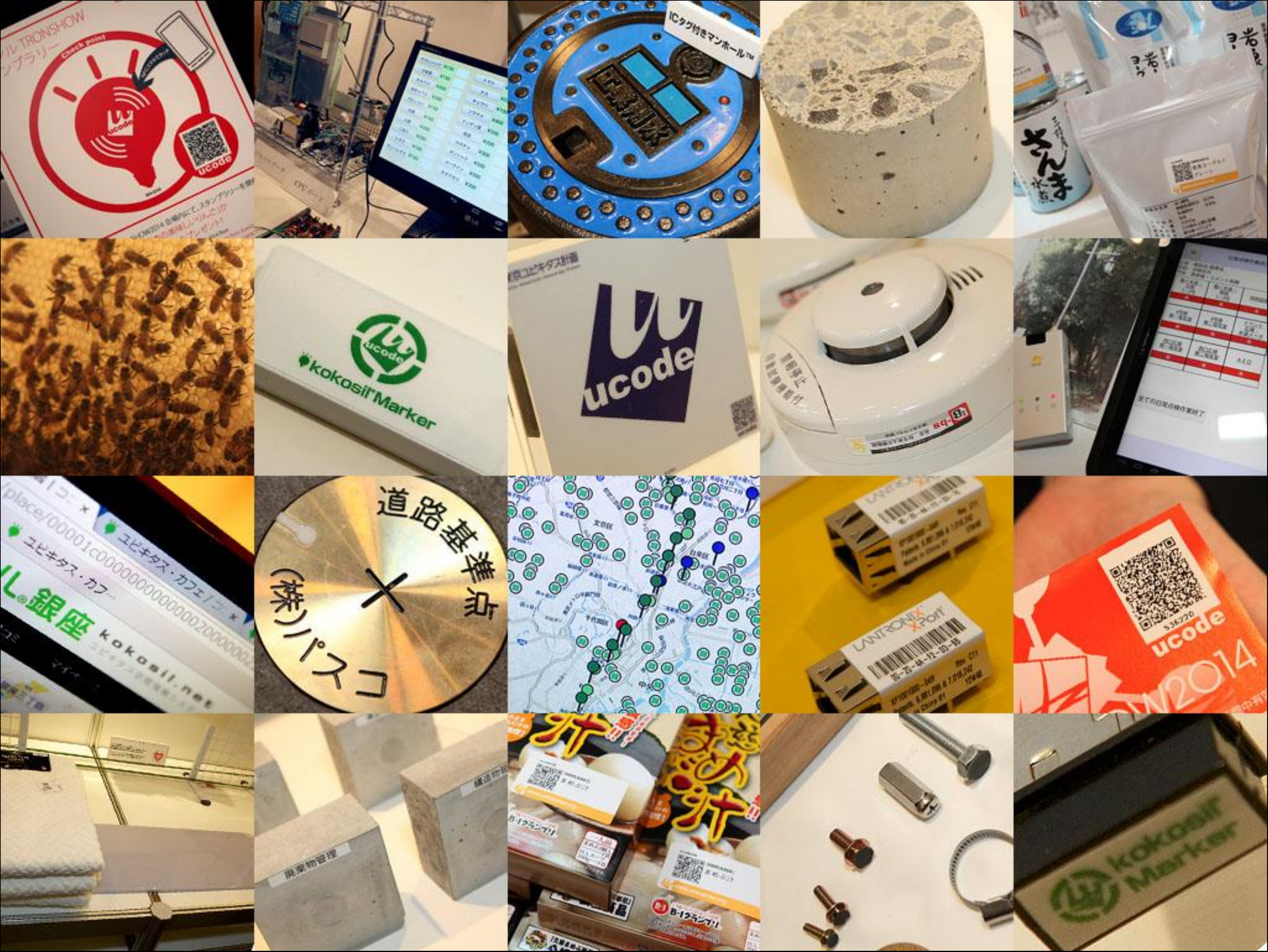
# Applications of ucode

- Applications that take advantage of inter-organization uniqueness of ucode
  - Registration service of long live houses and housing components
    (Better Living)
  - Pedigree Management of Horse Races (JAIRS, Japan Association for International Racing and Stud Book)
  - Medical Drug Traceability System (Benesis)
  - Intelligent Control Point (GSI, Geospatial Information Authority of Japan)


TRONSHOW
Check point
ucode
ICタグ付きマンホール™
さんま
kokosil Marker
ucode
ucode
AED
ユビキタス・カフェ
銀座
kokosil.net
道路基準点
(株)パスコ
文京区
千代田区
LANTRONIX XPort
ucode
2014
廃棄物管理
B-1グランプリ
kokosil Marker

# Research Projects on ucode

- R&D activities on foundation, and applications in Japan and overseas
  - Tokyo Ubiquitous Technology Project *kokosil*
    - Building Location-information infrastructure that uses ucode
  - Information distribution infrastructure (UNL/UCT)
    - Construction of open data platform based on ucode
  - IoT-A Project (EU FP7)
    - Led by VTT, EIT ICTLab, etc.
    - Adopted ucode as a part of resolution & discovery service in IoT-A architecture

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# ③ ucode Relation Model

# Ucode Relation Model (overview)

- In order to provide information service that retrieves various relationships between objects and places of the real world,
- A unique identifier (ucode) is assigned to things we want to identify
  - ucode is standardized as ITU Recommendation
- Real world (and virtual world) is modeled
  - ucode Relation model is a framework to model the real world in a digital framework

⇩

- Our "Ubiquitous Computing" concept is to utilize this model to optimally control the environment, while minimizing the explicit input of data

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# *ucode Relation Model (Definition)*

- Definition
  - A model to represent the context in the real world
  - by representing the relationships between ucodes, or ucode and a literal (called `atom’)
  - of ucode-identified objects, places and concepts
- ucR = ucode Relation
  - ucR model itself or a representation that uses ucR model are sometimes called ucR simply (informal usage)

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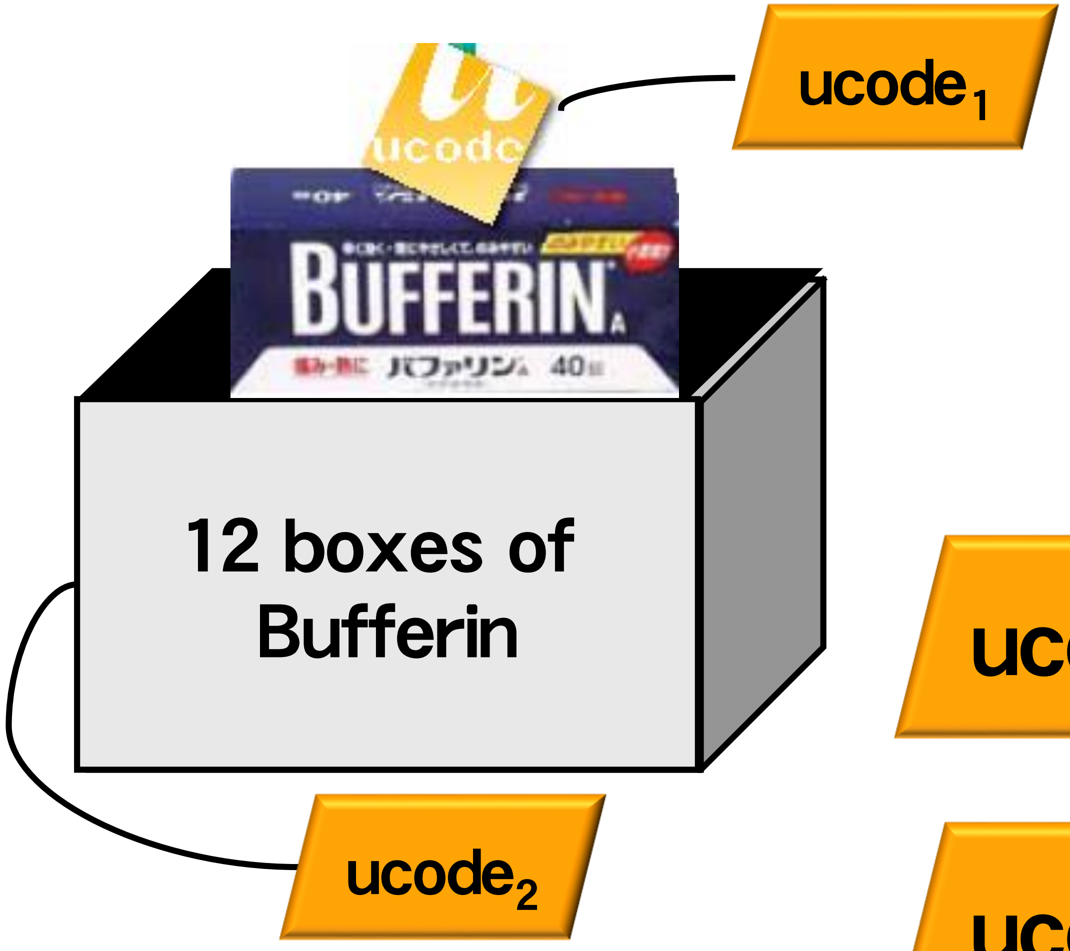
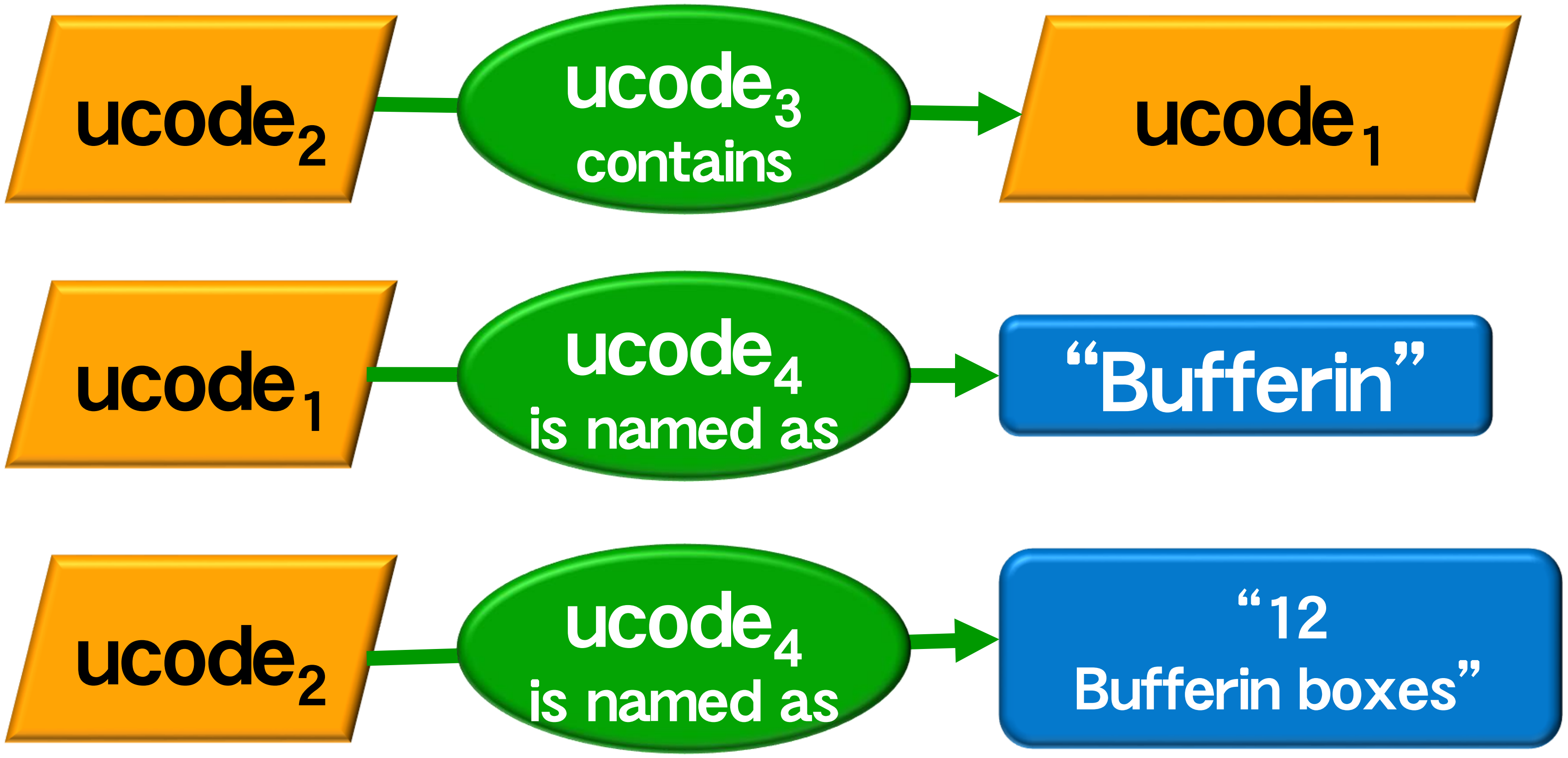
# Example ucR (Object)



ucode$_1$

12 boxes of Bufferin

ucode$_2$

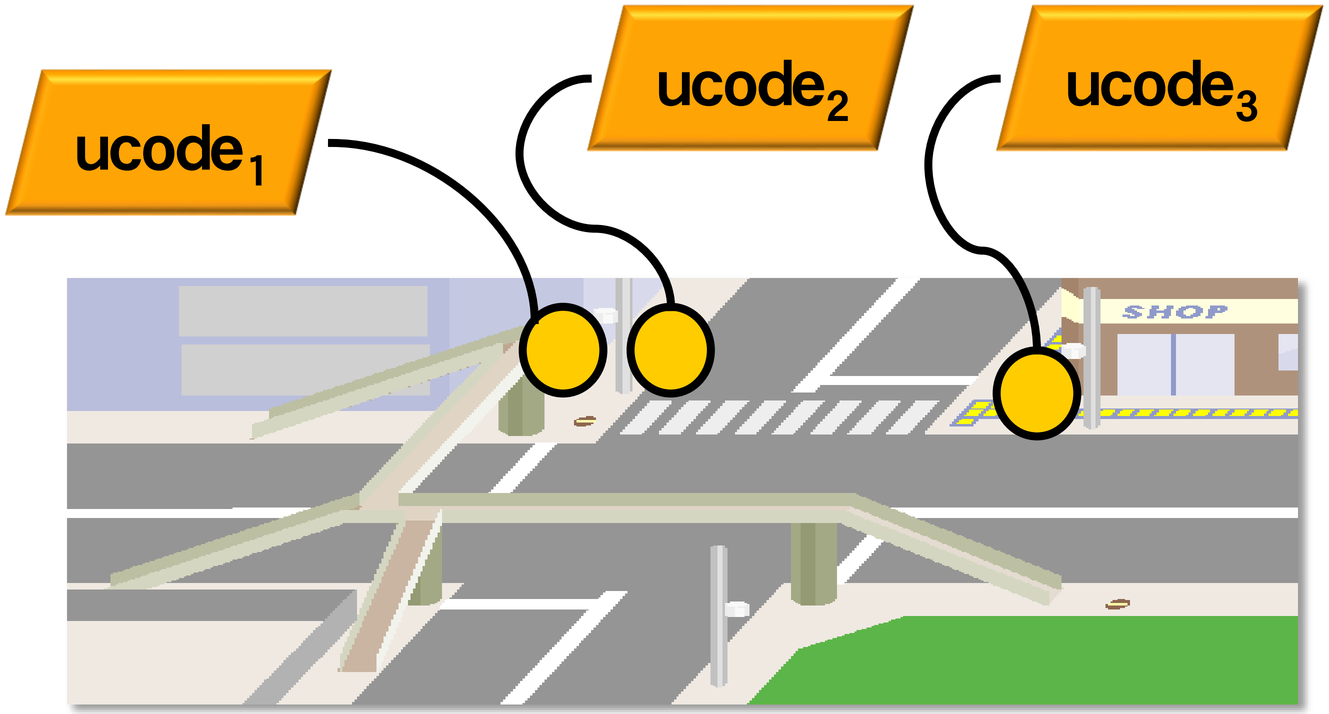


ucode$_2$ → ucode$_3$ contains → ucode$_1$

ucode$_1$ → ucode$_4$ is named as → “Bufferin”

ucode$_2$ → ucode$_4$ is named as → “12 Bufferin boxes”

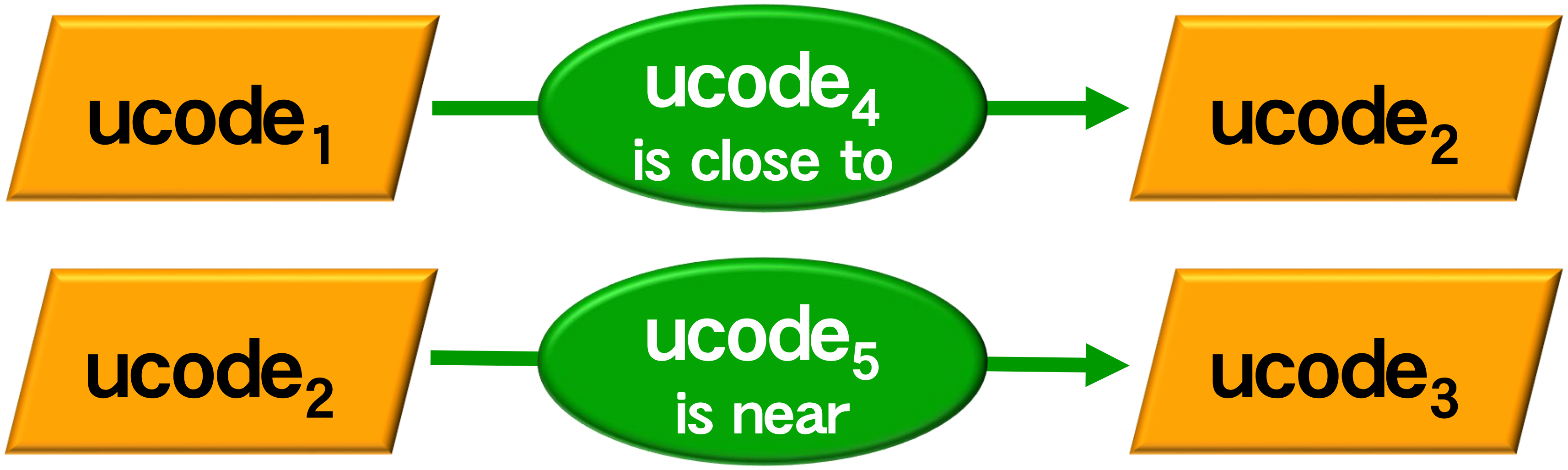
# Example of ucR (Place)



ucode$_1$

ucode$_2$

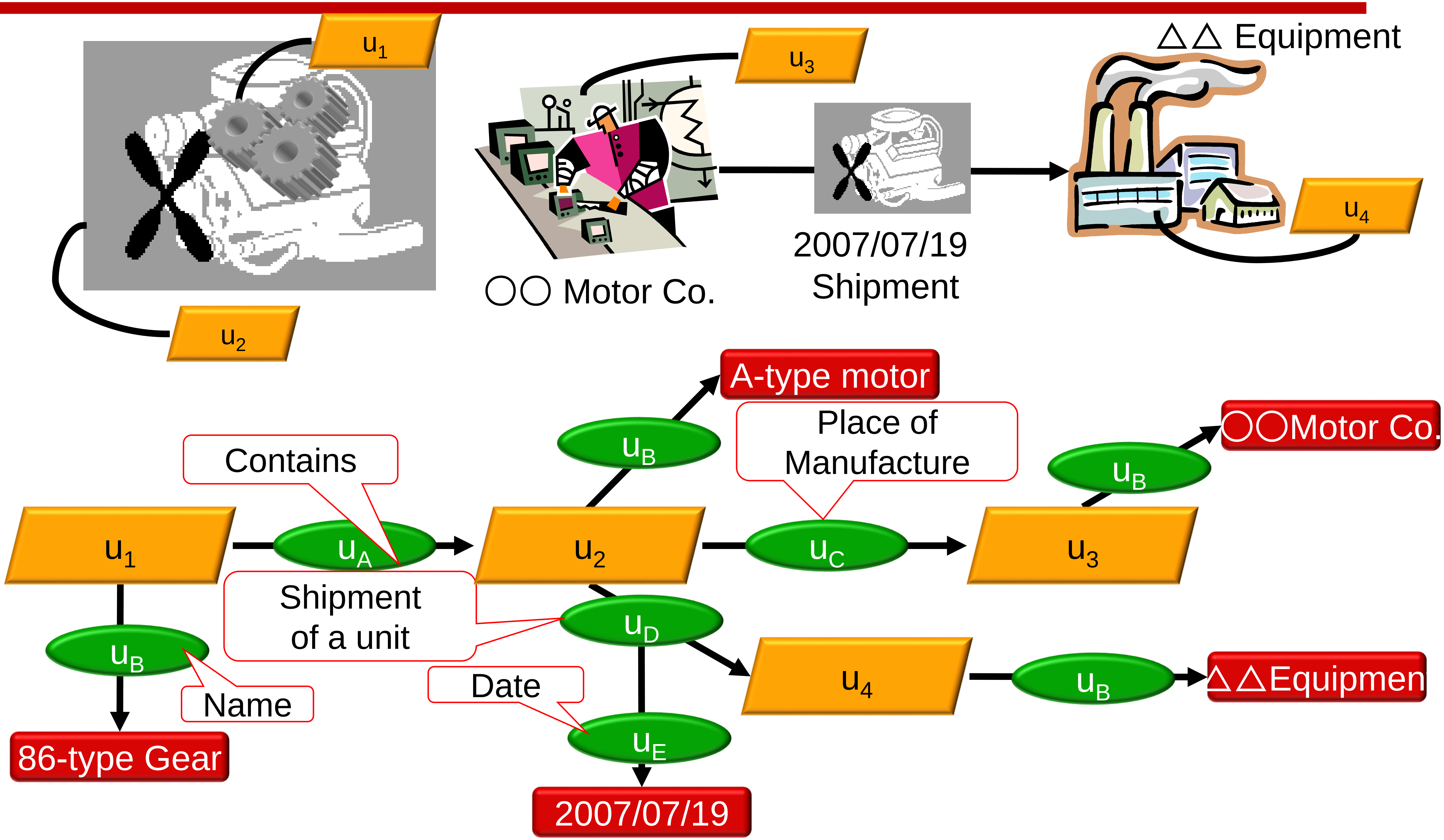
ucode$_3$



ucode$_1$ → ucode$_4$ is close to → ucode$_2$

ucode$_2$ → ucode$_5$ is near → ucode$_3$

# Example of ucR: A product and its parts



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# Important Points

- ucode permits a unique identification across boundaries of manufacturers and object categories
- ucode is never recycled: for one object, a unique ucode
- ucode can be issued anywhere by anyone:
  at manufacturer’s factory, on the usage spot, or by any business partners when authorized to do so
- Application provider can manage the access control what type of information can be retrieved by whom
  - E.g. For a part in a plant, it can be configured to allow maintenance personnel to retrieve the blueprint from the ucode while others may not even tell what it is, but may know that the part is used in a particular plant, or that it is used somewhere.

# Important Points

- ucode is tag-agnostic, thus able to choose tags considering the cost and importance of items
  - QR Code seal for small low cost parts
  - Laser-etched QR Code for small expensive parts
  - A unit consisting of such parts above, it could be tagged with RFID tag that can be read in the presence of back scattering metal surface
    - If you purchase by a large volume, one is available at 100 YEN (about one US dollar) range.
  - The plants that have many such units can be covered by radio markers, etc.

# Philosophical Underpinning of ucode

## “Definition by Example” is the basic concept

- ucR uses the existing objects in the real world as its foundation
  ucodes assigned to objects and places in the real world are at the foundation

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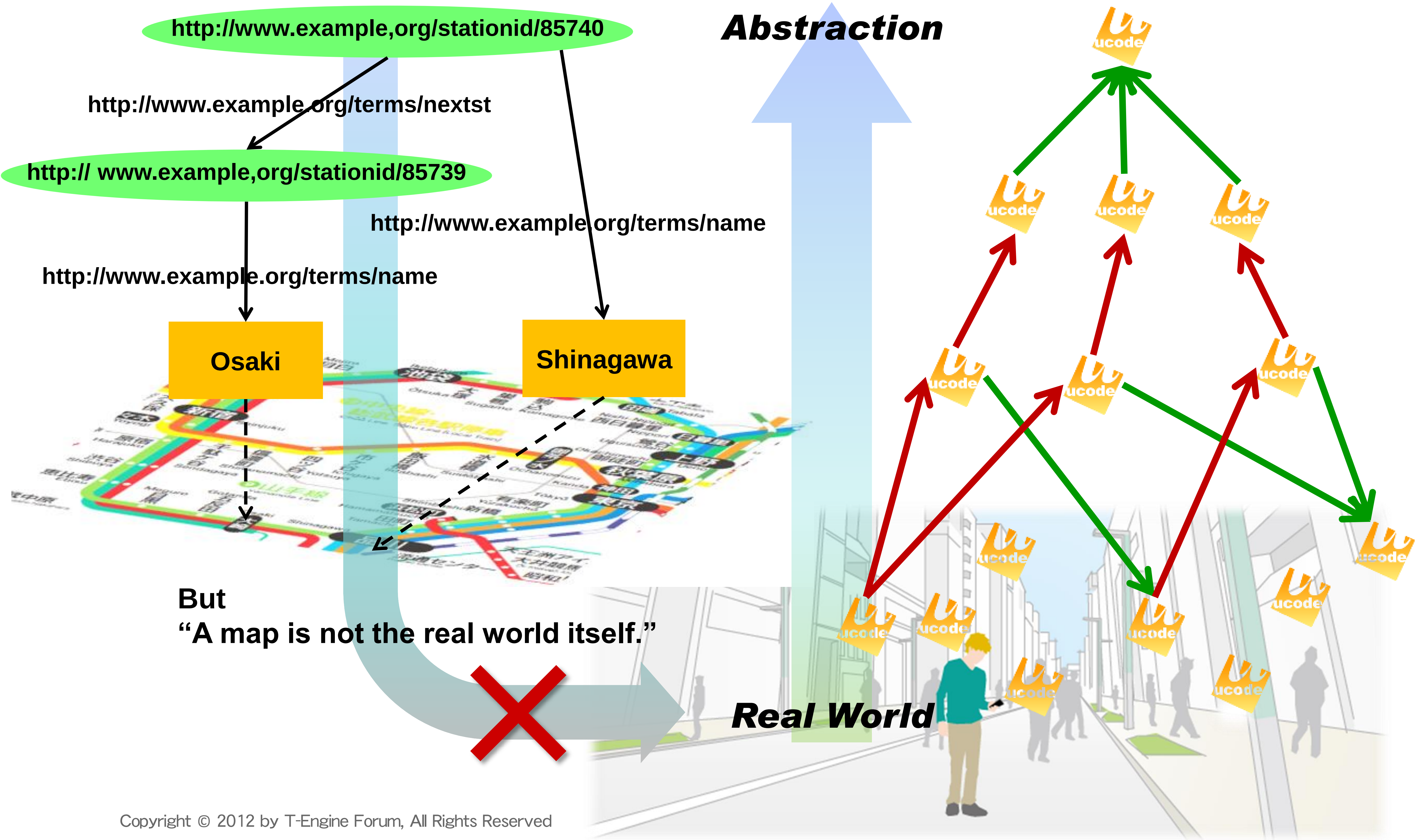
## Abstract concepts such as relationships are deduced from the facts in the real world

- We do not need a prepared vocabulary in advance

# Limitation of RDF and ucR

RDF：Tries to explain the real world from the abstract notion (top-down)

ucR：defines the abstract notion starting from the real world



http://www.example,org/stationid/85740

http://www.example.org/terms/nextst

http:// www.example,org/stationid/85739

http://www.example.org/terms/name

http://www.example.org/terms/name

Osaki

Shinagawa

But
“A map is not the real world itself.”

# ucR and RDF

**A view: ucR is an RDF, but uses ucode instead of URI to specify the resources**

↓

**RDF that needs vocabularies to model the real world is augmented by ucR**

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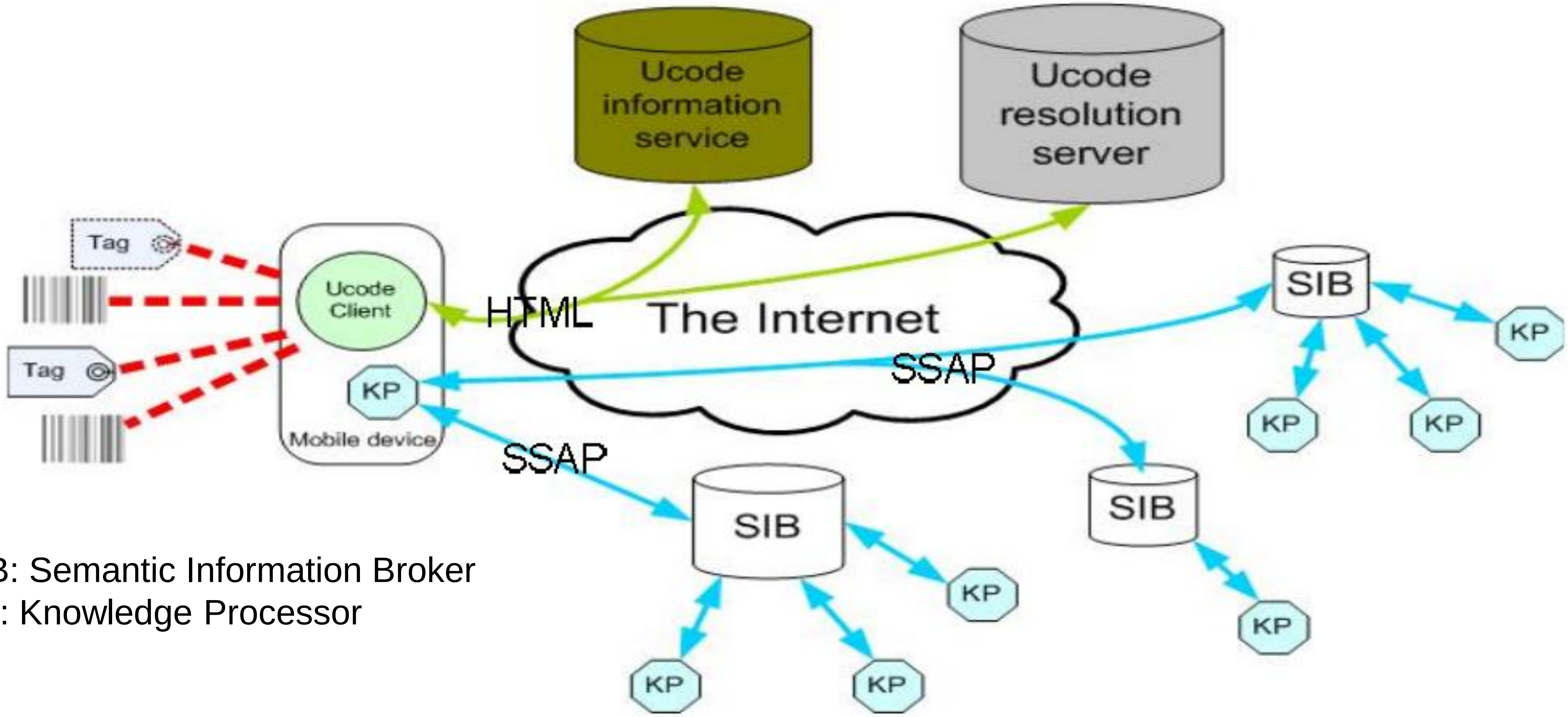
# Integration of uID and Smart-M3 (VTT)

- Combining uID and Smart-M3
  - Globally unique identification + semantic operations



SIB: Semantic Information Broker
KP: Knowledge Processor

Cited from: Viljamaa, E et al, “A Smart Control System Solution Based on Semantic Web and uID,” 2011

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# ④ uID Architecture: from U1 to U2

uID Architecture 2.0

# 2.0 of TRON Project

**To meet the new developments that make the IoT possible**

1. **Advances of technologies**
2. **Changes in the environment**
3. **Evolution of demands**

↓

**T-Kernel has advanced to T2, and uID architecture to u2**

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# 1. Advances of Technologies

## *Distributed processing of Big Data*

- MapReduce, Hadoop and other distributed data processing has become openly accessible

## *De facto standardization of open data processing protocol*

- REST, CoAP, and JSON have become common

# 2. Changes in Environment

It has become common to create new services by using Cloud, mashups, and open data

- The age has come where a new service is provided by building it on top of others

Favorable environment for startups

- It is easy to use the advanced technology
  AWS (Amazon Web Services), GCP (Google Cloud Platform), etc.

# 3. Evolution of Demands

Demands from open data

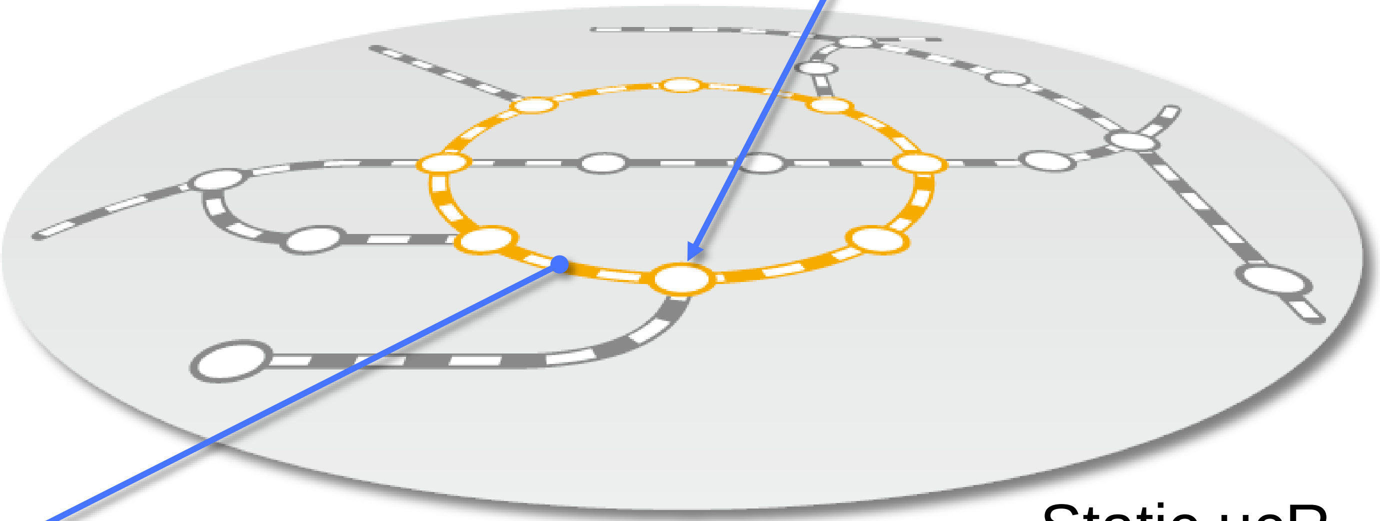
- It is now crucial to automatically collaborate with the large open data sets on the Internet

Demands from Big Data usage

- It is now necessary to handle stream-type temporal context information for transportation open data, etc.

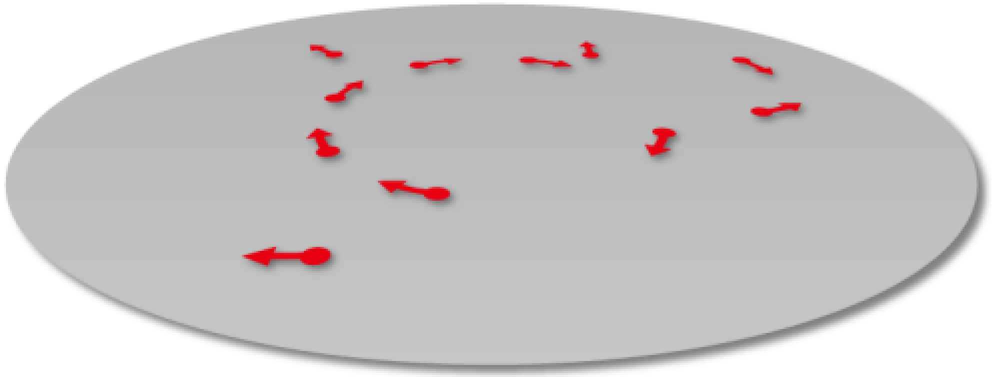
# Example of Stream-type Context

{Station102, $Ruc_6$, 35.627163, 139.722698}

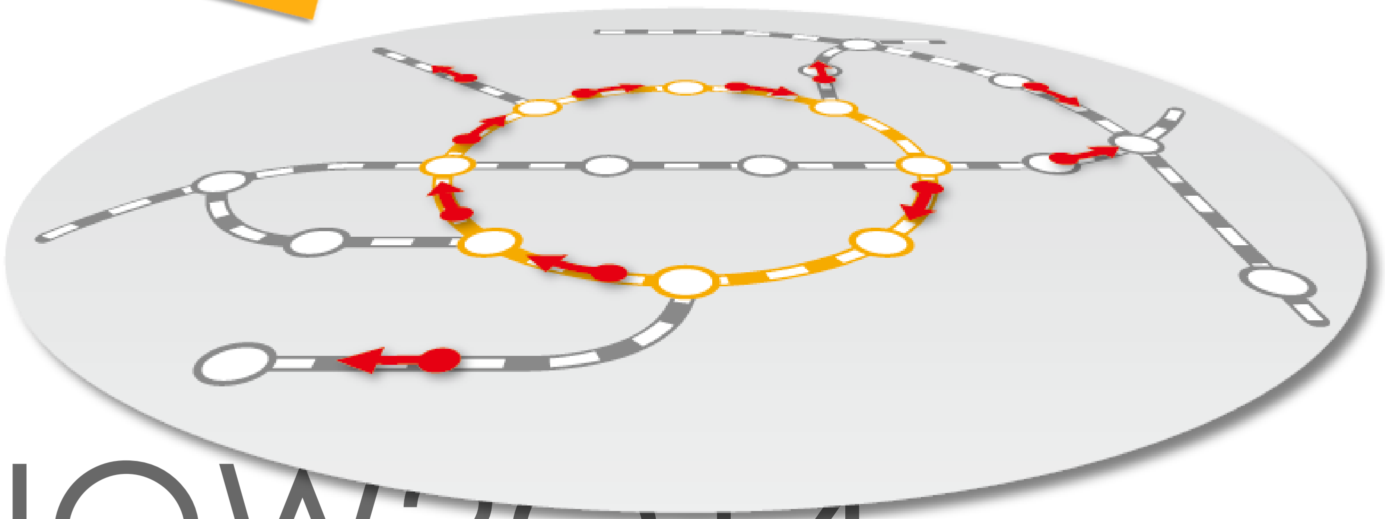


{IntervalF064, $Ruc_7$,Station102}
{IntervalF064, $Ruc_7$,Station103}

Static ucR



Overlaying Dynamic ucR…



- Location of a Station
  {$STATIONuc_5$, $Ruc_6$, geographical coordinates}
- Interval/Lines and Stations.
  {$INTERVALuc_3$, $Ruc_7$, $STATIONuc_5$}
  {$INTERVALuc_3$, $Ruc_8$, $STATIONuc_9$}

# Summarizing the "u1"

## *u1 has been a research project on model*

- u1 successfully provided the information model, the unified data representation for the IoT
  - ucode for globally identifying objects/notions
  - ucR (ucode relation) for common representation of data

⇩

## *We now need practical implementations based on the idea of u1*

- Must be implemented on the basis of current technology

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# *Hurdles for Realizing IoT*

- In order for a successful deployment of IoT, many of the hurdles need to be overcome
  - Stability of uID services
    - Performance on high loads, 24/7 reliability, …
  - Computational complexity and performance
    - NP hardness of subgraph matching, …
  - Management complexities
    - How to manage billions of ucodes
  - Protection against hostile behavior
    - DDoS attacks, access from malicious 3rd parties

↓

- “u2” aims at solving these practical issues

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# ④-1
# Stability of uID Services

# Stability of uID Services

- Affinity with latest cloud-computing technologies
  - IaaS (Infrastructure as a Service), OpenStack, load balancers, …
    - Amazon EC2, Google Compute Engine, …

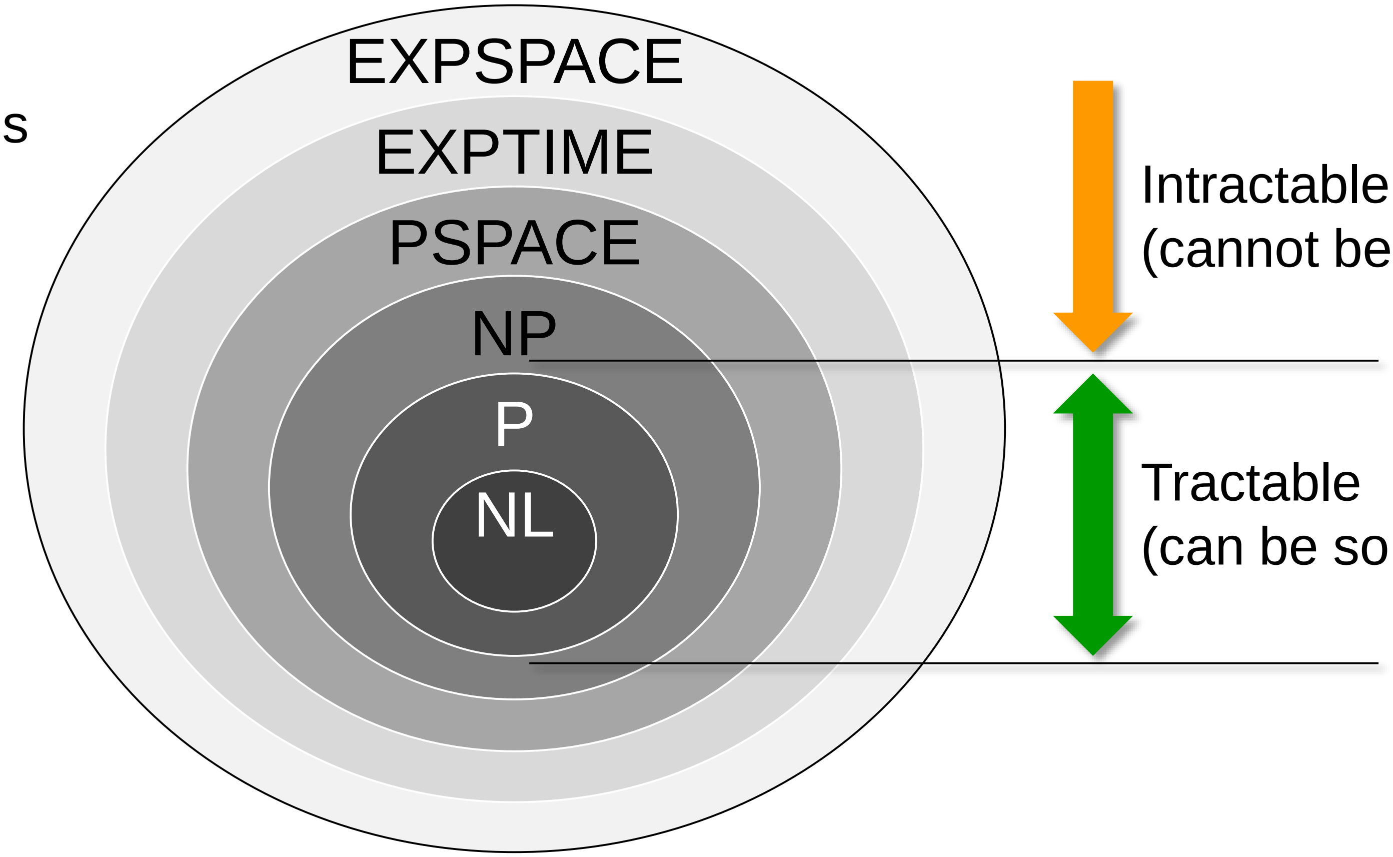
- u2 services are run on a IaaS service
  - Currently released to u2WG members

# ④-2 Computational Complexity and Performance

# Computational Complexity and Performance

- Large graph databases are intractable by nature
  - Known from the theory of “computational complexity”
    - Because of the NP-completeness of subgraph isomorphism problem, graph queries are NP-hard

Complexity Class Hierarchy


EXPSPACE
EXPTIME
PSPACE
NP
P
NL
Intractable
(cannot be solved efficiently for large data)
Tractable
(can be solved efficiently)

# Reasonable Restrictions on the query

- Again, u2 is designed for practical usage
  - Although based on the u1 model, the aim of u2 is to realize a practical IoT information framework
  - Thus, we need to solve this problem
- u2 provides a novel solution to this problem
  - In u2, ucR graph and queries is not generalized to have an arbitrary form, but is restricted to meet several conditions
    - ucR graph is forced to have vocabulary-defined restrictions (e.g., “contains” predicate must form a tree)
    - Queries do not have wildcard predicates that match across arbitrary number of vocabulary sets
  - These reasonable restrictions help to realize practical yet flexible IoT information framework based on the ucR model

# Basic Concept of U2

***Information Infrastructure that permits cross-queries to various APIs of DBs across organization and DB boundaries***

- ucR native database stores data that does not have a fixed set of queries, and is subject to complex queries This part is implemented by RDF database consisting of ucode triples

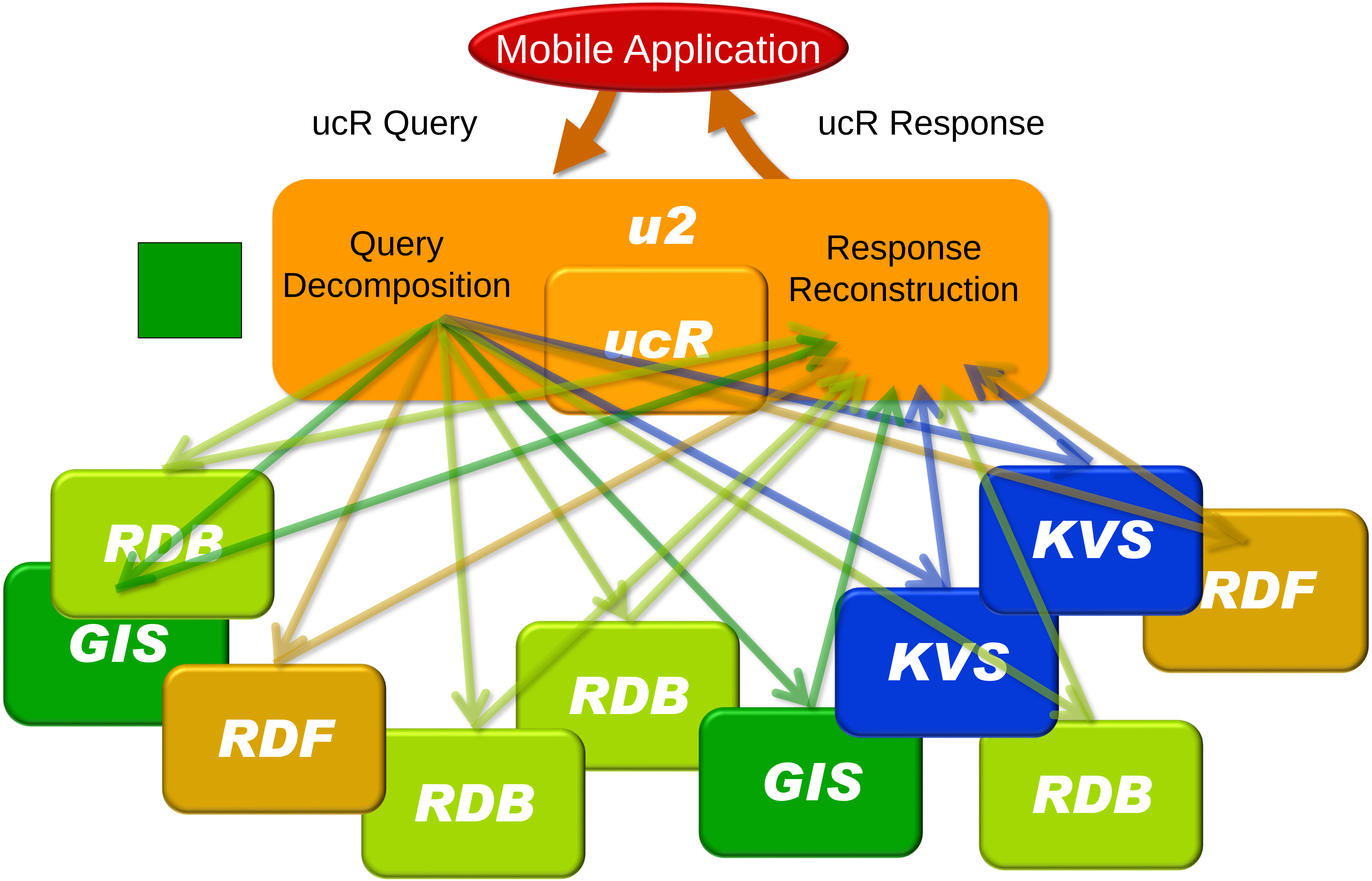
# Use of Legacy DBMS

- Data with well-defined patterns and internal constraints are stored in legacy DBMS optimal for data schemas
  - DB domain is identified with the vocabulary group of the well-established relationship with internal constraints
  - Existing DBMS can be plugged into the whole system, as a virtual ucR DB, using a simple wrapper
  - The virtual ucR DB integrates other DBs such as KVS DBs, GIS DBs which use different schemas different from the native ucR.

⬇

- This makes it possible to use algorithm and data structure best suited to the nature of data and applications
  - Search convenience stores within 1km radius of the current position → GIS:  R-tree is used.
  - Handling large volume of sensor data → KVS:  use Distributed Hash Table (DHT)

# Cross Query: Query Decomposition and Response Reconstruction



# ucodeRP2.0
# ucode Resolution Protocol 2.0

## Protocol to collect and integrate information necessary for the IoT

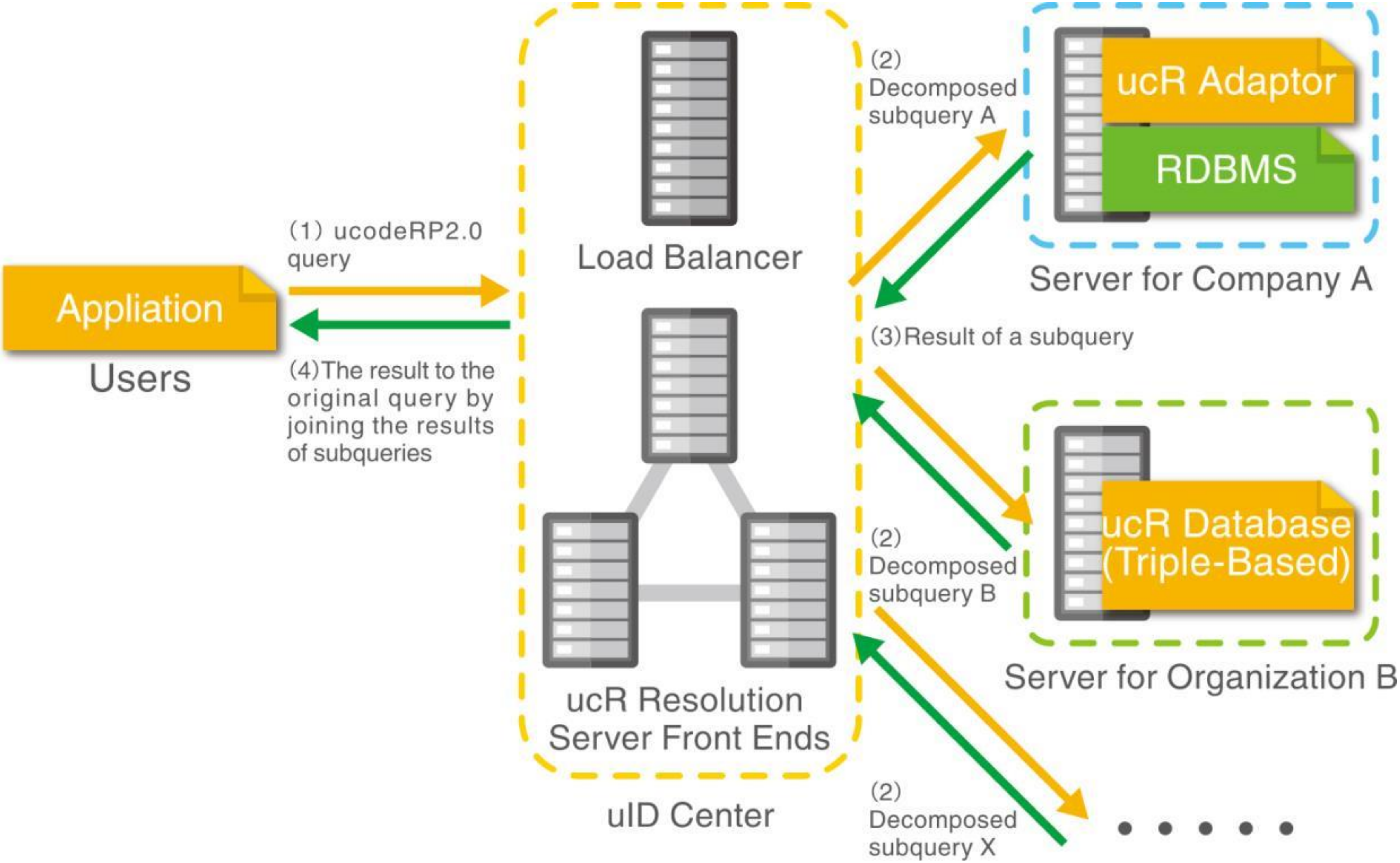
- A design meant for data usage across domain boundaries by means of open model of ucR (ucode relation) model

  This allows the federation of legacy RDBs and KVS DBMSs and permits cross queries.

# ucode Resolution Protocol 2.0

- ucode Resolution Protocol ver.2 uses standard technologies such as REST/CoAP, REST/HTTP, and JSON
- ucR queries are decomposed for DB domains (corresponding to particular sets of vocabulary) and subqueries are processed in each domain
  - ucR resolution server receives ucR query ad then interprets it, and decompose it into subqueries for each vocabulary group, and send each subquery to corresponding ucR adaptor
- Distributed Database with Hierarchy
  - ucR Resolution server front-end is made of distributed database, and if the database doesn’t understand a vocabulary, it will send the query to a resolution database in the upper layer in the hierarchy for resolution
  - For confidentiality, a local ucode resolution server can be set up in an organization. Then the whole steps of processing query and response can be performed locally

# ucodeRP2.0 Resolution Steps


Appliation
Users
(1) ucodeRP2.0 query
(4)The result to the original query by joining the results of subqueries
Load Balancer
ucR Resolution Server Front Ends
uID Center
(2) Decomposed subquery A
(3)Result of a subquery
(2) Decomposed subquery B
(2) Decomposed subquery X
ucR Adaptor
RDBMS
Server for Company A
ucR Database (Triple-Based)
Server for Organization B
• • • • •

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# ④-3
# Management Issues

# Management of large number of ucode

- How can we manage billions/trillions of ucodes?
  - Basically, ucodes are never reused
    - Hence, management efforts are often unneeded
    - Stale ucode data can be removed from databases without affecting other portions of data

↓

- In u2, basic solutions for ucode management are provided
  - Domicile ucR data service that can be used to define the basic information at the time of registration, is included in u2 service framework
    - E.g., owner info, context-aware access control information, …
  - Providing REST API for facilitating the issuance of new ucode

# ④-4
# Protection Against Hostile Behavior

# Protection against Hostile Actions

- Authentication and access control are inevitable consequences of using the open IoT environment as application infrastructure
  - E.g. : Desire to permit only the people living in a house and who are in the house at the moment to control home electronics appliances (kaden).
  - E.g.: Allowing access to health or disability information only to specific services (such as kokosil barrier-free navigation)

⇩

- A platform consisting of three-legged OpenID authentication model and Context-based RBAC
  - We are carrying out the design and implementation of the platform and the authentication and access control platform for IoT nodes and 6LBR, which requires light-weight implementation.

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# DareSil

## *The platform for authentication and access control of IoT nodes and services based on u2*

# Layers in the Architecture

- Application Layer (equivalent to SaaS)
  - Self-contained services provided to end users
  - This layer consists of applications that are tailored specific services, and the content and vocabulary that go with it
- Platform Layer (equivalent to PaaS)
  - This layer provides special functons and libraries targeted to specific set of objects, locations, ad content, and specifically provides API to perform cross query over variety of data efficiently by way of uID Center
  - It defines and manages the attribute of “original data”（本籍データ？） of ucode for each target data category
- Infrastructure Layer（equivalent to IaaS）
  - This performs the resolution according to ucodeRP2.0, and returns appropriate data

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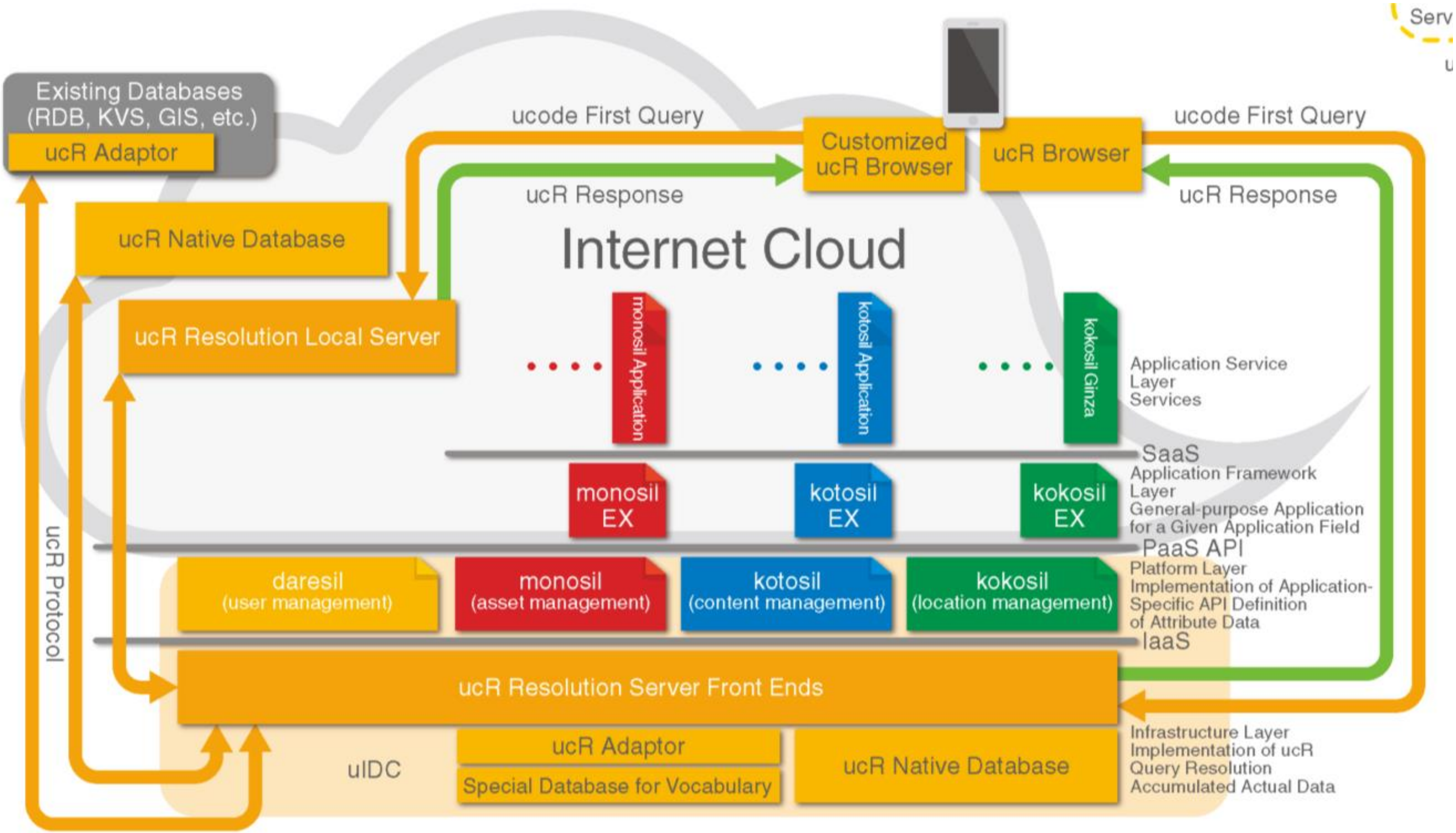
# Layers in u2 Architecture



# Five Application Platforms

- kokosil
  - A platform to manage the locations, and the relationship among them.
  - It handles the coordination with existing location-information and map-information services such as GIS.
  - It acts as the basic platform for location-information services, sensor network applications
- monosil
  - A platform to manage tangible objects and  the relationship among them
  - It handles the coordination with existing asset management services that use ISBN, etc.
  - It acts as the basic platform for cross-organization traceability service, logistics, and manufacturing management, etc.
- kotosil
  - A platform manage contents
  - It handles the coordination with existing content sites such as Wikipedia, and Twitter
  - It can act as the base of ucR-based content application and can work with kokosil to produce a guidebook application, or work with monosil to produce a catalog application
  - kotosil can be called from other applications: e.g., kokosil can use the content related to a location
- daresil
  - A platform to manage users, user groups, and organizations and the relationship among them.
  - It handles the coordination of authentication with existing SNS, and others.
  - This is used by other applications for user management and access control management.
- kachisil
  - A platform to manage accounts for fee-based services.  This is used by other applications.
  - It handles the coordination with existing credit services.

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# ⑤-1
# Realizing the IoT by u2

## ***Future potential of u2 and open data***

# u2 for data governance

↓

# as infrastructure for open data

**An infrastructure to permits cross queries to variety of DBs across organizational and DB domain boundaries**

- It accepts standard a ucR query from an application, decomposes the query into subqueries, sends subqueries to DBMSs where they are processed, constructs the response by integrating the responses, and returns it as the response to the original ucR query

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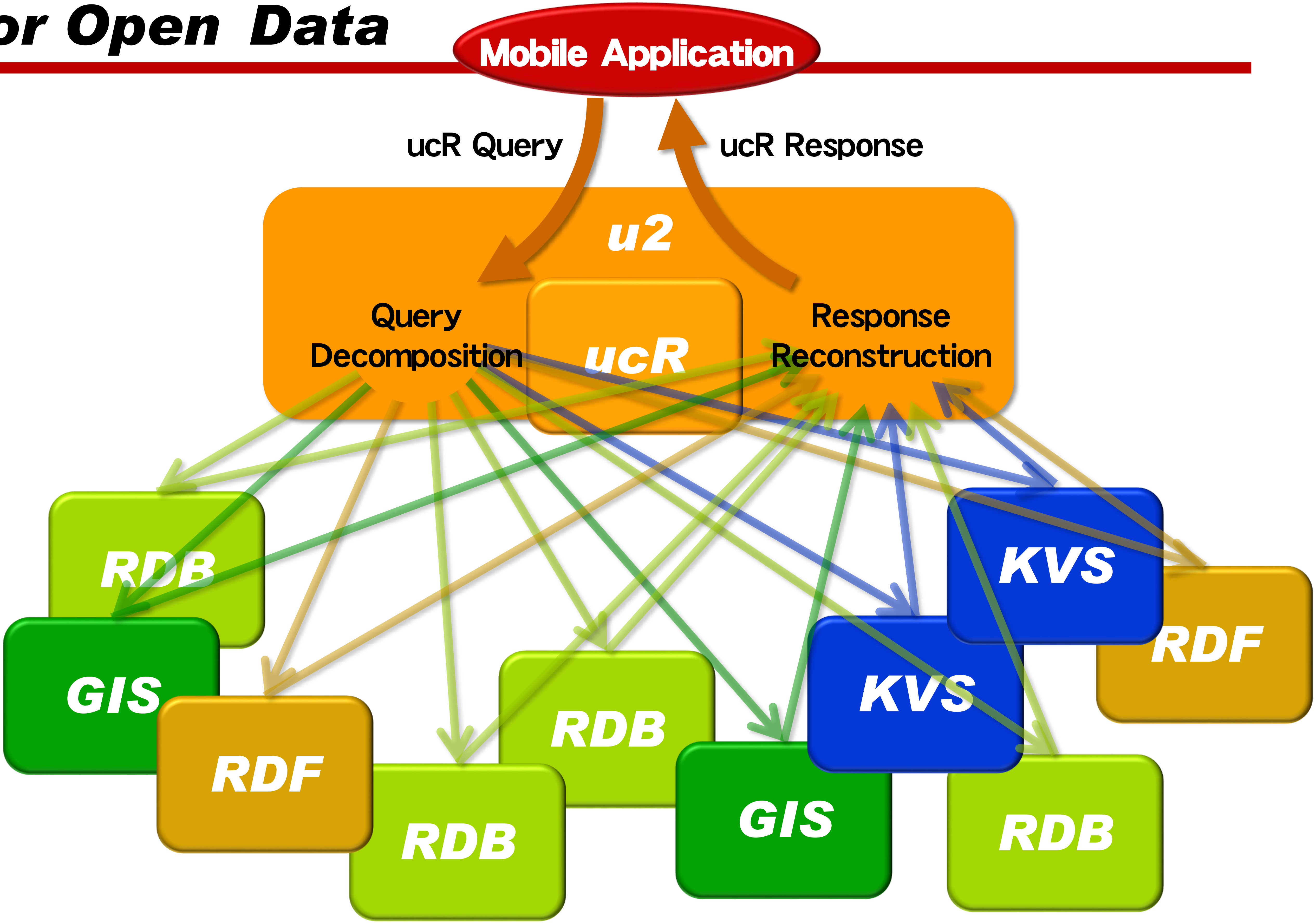
# Infrastructure for Open Data



# Future potential of u2 and open data

- Many data sets will become available as open data
- Their federated usage will be an issue
  - E.g. How to know the average value from all the sensors in an area
  - Obtain the list of buildings in the given area from open GIS,
  - Then, for each building in the list, invoke sensor API to collect data and record them, wait for the answers for all the queries, and once all the answers are in, then perform the statistical processing.
  - Such federated actions are difficult for mobile application with limited available resources

- If u2 handles cross queries and response construction within a single standard ucR query,
- varieties of applications can be built easily

# ⑤-2
# Realizing the IoT by u2

***Future potential of u2 and open API***

# High-speed, Low-cost and Always-on Network

***Home electric and electronic appliances will always be connected with cloud***

- For example, it is easier to conduct the collection and utilization of electricity usage at home by connecting all the home electric and electronic appliances with cloud instead of managing and analyzing the data by the installed server at home.

↓

***Embedded devices as "Bridges between cloud and the real world" in the IoT paradigm***

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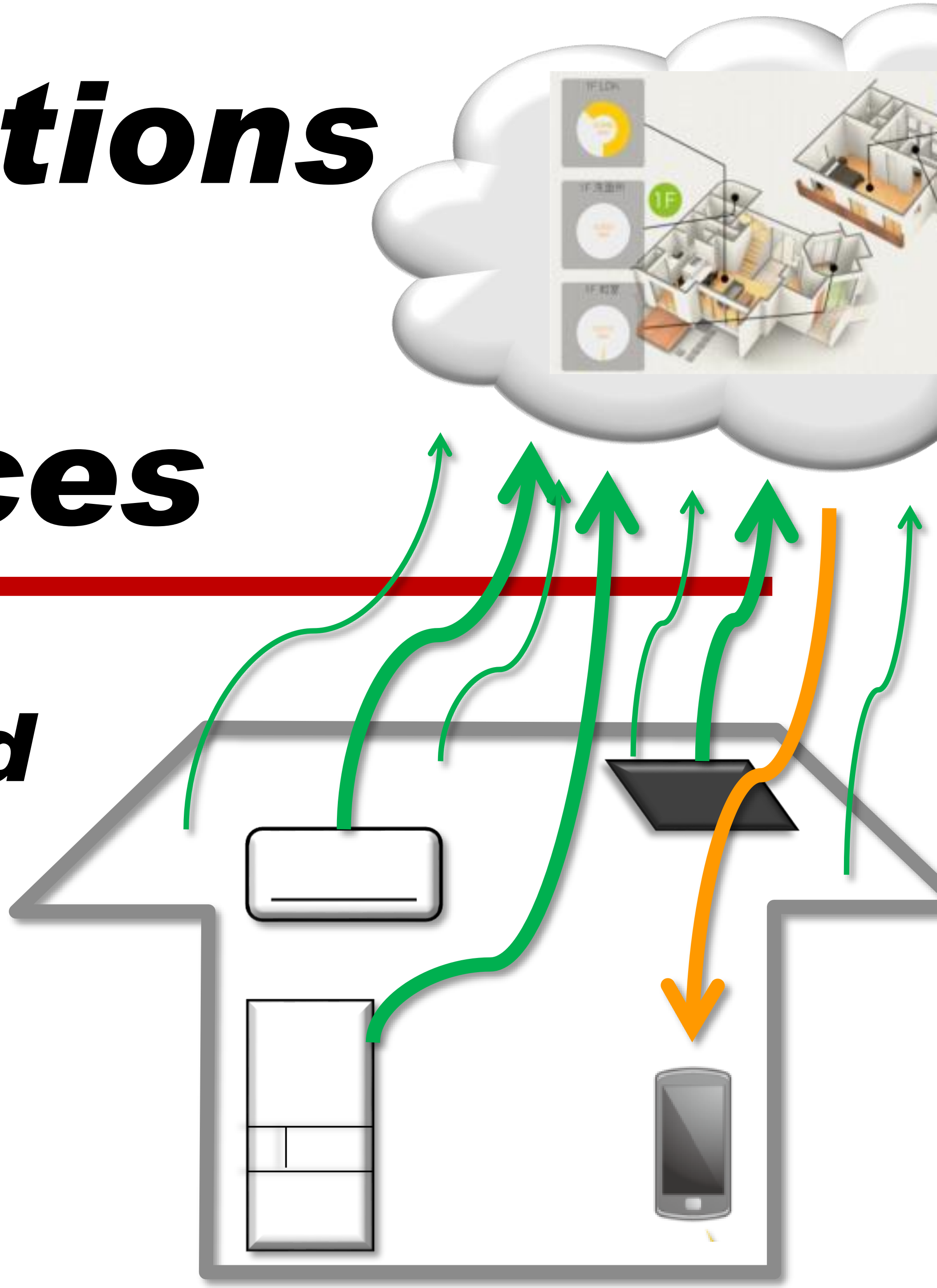
# Unbundling functions by OPEN API of Embedded Devices



**Data processing by cloud**

**UI by smartphone**

**Specialized function by embedded device**

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## u2 for the Governance of Control

⇩

## Used as part of the upper layer of access control

Consolidation of information, context-awareness

Access control of devices and information

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# Access Patterns to open API of Embedded Systems

## Via Web

- Accessing system-provided API
- Devices are accessed by means of vendor-provided web site for control and management

## Local Direct

- Application issues API call directly to the device on the local network

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# ***Limiting Access Control through u2 Only***

- Via Web
  - Integration and wrapping of OpenID-style authentication delegation of the original web API

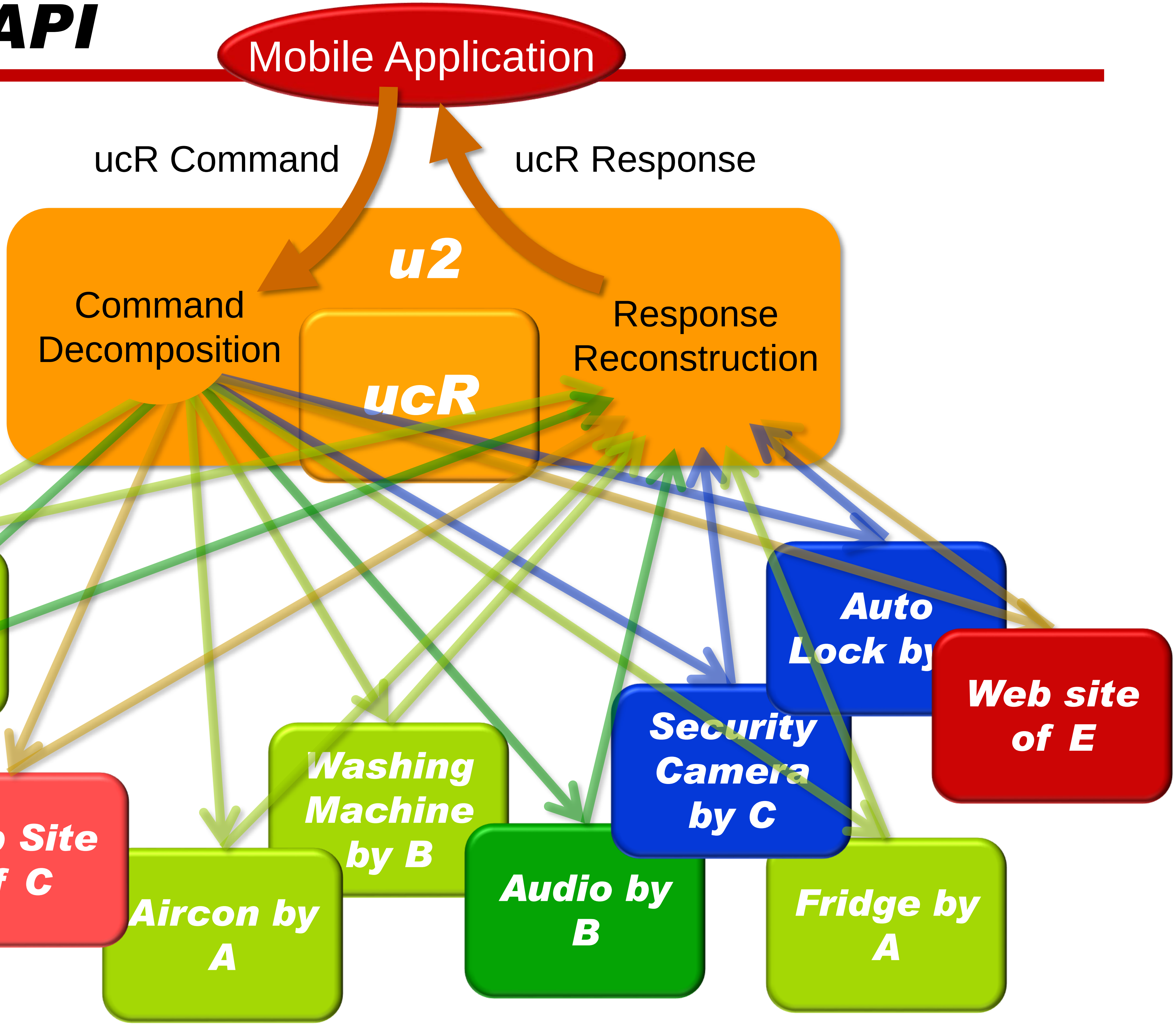
    ↓

  - We can access devices with very universal vocabulary which is converted to the each device’s API, so we can use the APIs from different vendors in a federated manner.
- Local Direct
  - U2 realizes the integration and wrapping of API and the input and retaining of access key

    ↓

  - Access key is not exposed to user application, and so the embedded application does not have to handle complex access control only with the key.

# As Access Control Infrastructure for Open API



Mobile Application

ucR Command

ucR Response

u2

Command Decomposition

ucR

Response Reconstruction

VCR by B

TV by B

Web Site of C

Aircon by A

Washing Machine by B

Audio by B

Security Camera by C

Auto Lock by

Web site of E

Fridge by A

# u2 as open access infrastructure

***Aggregation of information and context awareness***
***→ ucode Resolution Protocol (ucodeRP) 2.0***

***Access control management of devices and information***
***→ daresil***

# In the distant future, self-organizing world description

## *Generating "Predicate" from Big Data*

- In an era when we can tell from statistics that A and B has a certain relationship, then it is desirable that the predicate for the relationship and the database domain that handles the related data are generated automatically for efficiency reasons

⇩

## *The merit of ucode is that it can be easily assigned to something that is generated by application on the spot*

- It is not necessary to attach the meaning, "definition" and "name", to such relationship..

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# TRONSHOW2015

Dec 10 to Dec 12, 2014

TRON Project 30th year anniversary！

TRON Symposium

***u2 API will be released.***