

## Deployment of ubiquitous computing

We have established a non-profit international forum for ubiquitous computing technologies, T-Engine Forum. A section of T-Engine Forum which handles standardization, system operation, and promotion of ubiquitous ID architecture is Ubiquitous ID Center. Currently, the number of forum members are about 500 world wide. We cooperate with these member companies for R&D, standardization, and establishing and/or managing the ubiquitous computing infrastructure. T-Engine Forum and Ubiquitous ID Center are supported by organizations in several countries, and we have already established satellite centers.

### T-Engine Forum, Tokyo

<http://www.t-engine.org/>

### Ubiquitous ID Center, Tokyo

<http://www.uidcenter.org/>

### TEADEC: T-Engine Application Development Center, Singapore

<http://www.teadec.com.sg/>

### KTEC: Korea T-Engine Center, Seoul

<http://www.t-engine.co.kr/>

### Ubiquitous ID Center China, Beijing

<http://www.uidcenterchina.org/>

## Laboratory profiles

### Director

Ken Sakamura (Professor, the University of Tokyo)

### Managing boards

**Director:** Ken Sakamura (Professor, the University of Tokyo)

**Vice Director:** Noboru Koshizuka (Associate Professor, the University of Tokyo)

**R&D board:** Risshi Morokuma

**Business board:** Koichi Nakano

**Strategic planning board:** Jun Yamada

**International Liaison board:** Chiaki Ishikawa

### Establishment

January, 2002

### The Number of Researchers

50

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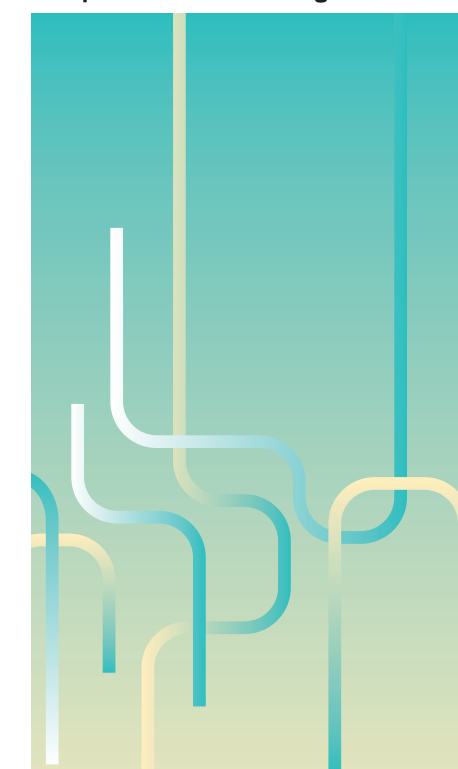
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# Creating the future

with Ubiquitous Computing Technology

The logo for the Ubiquitous Networking Laboratory (UNL) consists of the letters 'UNL' in a stylized, rounded, teal font. The 'U' and 'N' are connected at the top, and the 'L' is separate.

Ubiquitous Networking Laboratory



<http://www.ubin.jp/>

YRP Ubiquitous Networking Laboratory

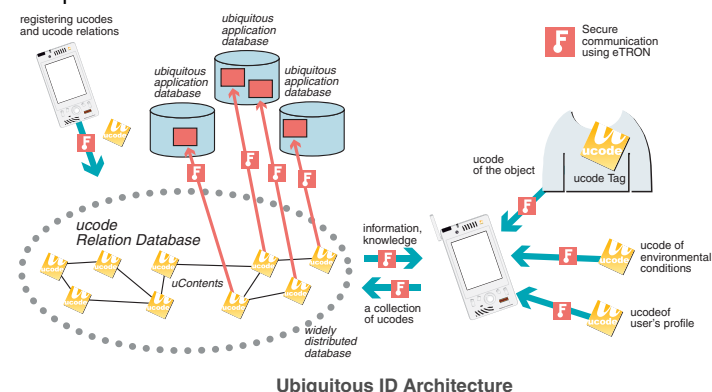
## Mission and goal

The main mission of YRP UNL (YRP Ubiquitous Networking Laboratory) is to realize the vision of ubiquitous computing. We will contribute not only to research and development but also to business model, social design, and technology promotion of ubiquitous computing environment. We bridge the gap between the physical world and the virtual world, and establish context-aware computing which uses real world context information for a sophisticated information processing and an environmental control.

## Ubiquitous computing architecture

### ucode architecture

Our ubiquitous computing architecture, Ubiquitous ID architecture, consists of ucode tags including ucodes, ubiquitous communicators, and ucode relation databases. The most important feature of our ubiquitous computing architecture is the convergence between automatic identification technology and computer networks.



### ucode : ubiquitous code

The centerpiece of the automatic identification technology in Ubiquitous ID architecture is ucode. We assign ucode to everything to identify it, such as objects, places, time, organizations, contents, characters, and environmental conditions. In our ucode model, our entire world is described as relations and/or networks among ucodes.

### ucode relations database

The relations and the networks of ucodes constituting a huge database are managed by ucode relations database which is implemented and distributed all over the world.

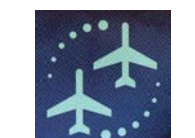
### ucode tags

We give the ucode to the real world using various ucode tags such as barcode, QR code, RFID, contactless smart card, and active tags. The ucode tags support computers to identify the real world automatically. This is the technical foundation of context recognition of ubiquitous computing.

Certified ucode tags of Ubiquitous ID Center



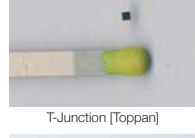
Barcode tags (Toppan, DNP, Sato)



Digital watermark tags (NTT)



uchip (Hitachi)



T-Junction (Toppan)



MB89R116, MB89R118 (Fujitsu)

## Ubiquitous information services

Using the ucode tags containing ucode and ucode relations database, we can take advantage of ubiquitous information services as follows. Firstly, we obtain a collection of ucodes by communicating or recognizing ucode tags. (Context-recognition phase) Next, by retrieving ucode relations database, we can obtain the relations or the networks among the collected ucodes. These relations or networks just represent the situation or condition of the real world. (Context-aware phase) Ubiquitous communicator (UC) is a human-machine interface between ubiquitous computing environment and users. UC manages ubiquitous information services.



eTRON/16 (U-Tokyo, YRP UNL, Renesas, DNP)



uchip R/W (Hitachi ULSI)



MB89R119 (Fujitsu)

## Ubiquitous computing applications in the real world

Ubiquitous ID technologies are finding their way into a wide variety of environments, from homes to automobiles. We are applying our technology to many applications to evaluate it.

### Autonomous movement support

ucode tags embedded in pavement stones, street signs and lamp posts will supply users with location-specific information "anytime, anywhere, to anyone". In several cities in Japan, thousand of ucode tags and road sensors have been embedded in the pavement, street signs, and lamp posts, providing information to tourists about historical sites and to the disabled about obstacles. This project is supported by Japan's Ministry of Land, Infrastructure, and Transport.



Autonomous movement support project

### Increasing food safety by ubiquitous ID technology

Ubiquitous computing technology helps us in assuring food safety. This is because it can increase the visibility of total food life cycle such as production, distribution, sales, and consumption, by managing information of the food. For this purpose, we put RFIDs or barcodes onto the food package, which keep the correspondence between the food and its information in databases. Usually, the database contains the record of how the food was produced and distributed. This information is mainly used for food safety management, supply chain management, and information disclosure to consumers. This project is supported by Ministry of Agriculture, Forestry and Fisheries of Japan.



Food traceability project

## Safety assurance in the hospital

Today, there are many accidents in hospitals because of several reasons. Some of them are caused by the mistakes of doctors and nurses. For example, a nurse may give wrong medicines to a patient by misreading a prescription by a doctor. To prevent this mistake, we have tried to apply ubiquitous computing technologies in the hospital. We put a ucode tag onto medicine package, and store the data of the medicine. Before a drug administration by nurse, he/she obtains the ucode in the RFID using UC to check the compatibility with the given prescription.



Safety assurance in the hospital

### Supply chain management

Physical distribution of goods is among the most significant application of ubiquitous computing. To streamline goods inspection in receipt and shipment, we attach RFID tags to each of products and distribution lots, and utilize the anti-collision feature whereby many RFID tags are read and written simultaneously in order to process the tags collectively.

### Smart house

The main goal of our smart house project was to design and realize an environmentally friendly, energy saving smart house in which the latest ubiquitous network computing technologies developed by our ubiquitous id project could be tested and further refined. This research resulted in Toyota Dream House PAPI. (<https://toyotahome-net.com/papi/tur/index.html>)



Smart house (Toyota Dream House "PAPI")

## Ubiquitous computing applications in the real world

### Embedded computing

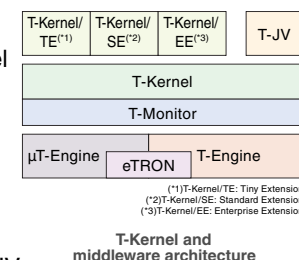
**T-Engine** : T-Engine is a complete platform for ubiquitous computing. It enables developers to rapidly build ubiquitous computing solutions of hardware and software. Among them are four standard T-Engine of varying physical dimensions for different application areas: standard T-Engine, micro-T-Engine, nano-T-Engine, and pico-T-Engine



T-Engine Platforms (Standard T-Engine, micro T-Engine, nano T-Engine, pico T-Engine)

**T-Kernel** : T-Kernel is the standard real-time operating system for T-Engine. The major feature of T-Kernel is that it is a standardized single source kernel, which assures the portability of middleware or application software among different T-Engine-based embedded systems. Another feature is its scalability. Today's embedded applications range from a small,

single-purpose embedded system to a large-scale server system. T-Kernel is so scalable that it can cover—with a single kernel architecture—a wide array of systems. We have already developed several middleware components upon T-Kernel including T-Kernel Standard Extension and T-JV.



### Ubiquitous communicator

**Ubiquitous communicator** : To navigate ubiquitous computing environment, YRP UNL developed the Ubiquitous Communicator, a hand-held device that can read ucode tags and retrieve the relevant data from the uID Centers server databases. The standard UC has a host of features including WiFi (Wireless Fidelity), VoIP (Voice over IP), IrDA (Infrared Data Association), and biometric reader. Apart from the PDA-like model, YRP UNL developed a cell phone model (UC-Phone) and a wrist watch style (micro-UC).



Ubiquitous Communicator (PDA Model) and UC-Phone

### Ubiquitous security

**eTRON** : eTRON is used to protect ubiquitous computing environments from malicious crackers. It is a wide-area distributed system architecture based on tamper-resistant hardware. eTRON chip is installed in T-Engine and UC to prevent wire tapping and falsification. It also ensures that electronic information is safely delivered through insecure network channels, like the Internet.

### Realtime network

**UNP** : We have developed a next generation light/secure/high-level network protocol suited for controlling devices, called UNP (Ubiquitous Network Protocol). UNP will be used by nano-T-Engine, which is a small network node controlling sensors and various devices via a network in a ubiquitous computing environment. UNP's target is realtime network of control systems in which a relatively small amount of realtime data flows such as home control, building management, factory management and in-vehicle networks.

### Sensor network

**DICE** : DICE is the smallest unit of ubiquitous computer for sensing and controlling in a ubiquitous computing environment. DICE, an ultra-tiny computer, requires very low power consumption so that it can work for a year without replacing the onboard small battery. The wireless network of DICE has an anti-collision function that allows 1,000 DICES to be used simultaneously.



The smallest sensor network node in the world "Dice"



nano T-Engine equipped with UNP (Ubiquitous Network Protocol)