# Embedded System Solutions for Creating New Social Values in the Age of IoT

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Abstract

Business environments vary continuously and are becoming more and more complicated. While a mechanism that can deal with environmental change is required, IoT (Internet of Things) is expected to be capable of creating new values by solving various issues. To implement the world of IoT, the embedding technology connecting the real world and IoT is of increasing importance. This paper introduces system solutions for achieving effective IoT that can deal with the constraints effected by various utilization environments, etc. This is done by implementing functions such as sensors, data communication and data processing.

Keywords

IoT, ICT, HCD, CyberWorkBench, FPGA (field-programmable gate array)

## 1. Introduction

NEC has always adopted the approach of going ahead of the times by predicting imminent changes to society. From computers and networking equipment to cellphones and satellites, we have developed numerous devices and systems. Throughout the history of more than one century, we have developed our well-known technologies such as image recognition, communications and security and the technologies for embedding them optimally in our products. We have also built large-scale systems that can integrate IT infrastructures and applications.

We are currently merging a variety of technologies including SDN (Software-Defined Networking) and cyber security that we have developed using our most advanced ICT assets. The results will be deployed in every conceivable domain in order to support the approaching age of IoT (Internet of Things).

## 2. Embedded System Solution Menu

We aim to assist customers from the product planning stage, support their product development by coordinating the development of required technologies and also to assist in the improvement of mass-production systems. **Fig. 1** shows the main embedded solutions menu that we are currently providing for our customers.

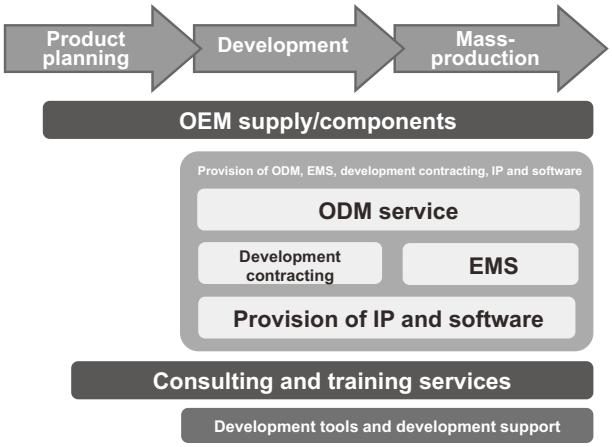


Fig. 1 Embedded system solution menu.

### 2.1 OEM Supply and Component Provision

The OEM supply and component provision (**Fig. 2**) contrib-

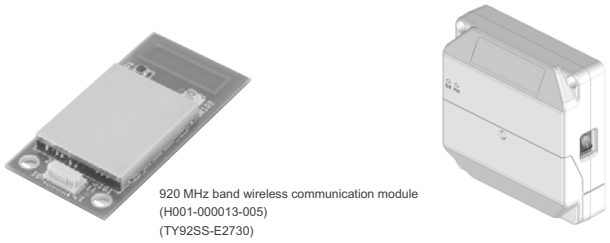


Fig. 2 Wireless communication for sending collected sensor information (left) and energy management unit for integrating the energy measurement and control functions (right).

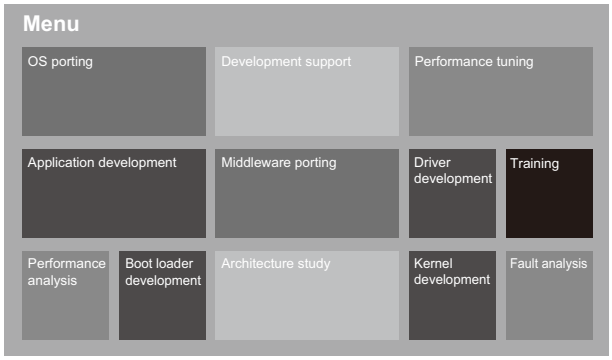


Fig. 3 Embedded software development menu.

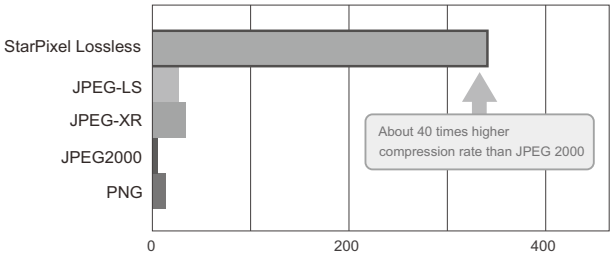


Fig. 4 High-speed, high-quality image codec IP.

utes to products of our customers in their early market release and further added value improvement.

### 2.2 ODM, EMS, Development Contracting, Software Provision

According to the request of each customer, we are commissioned to provide support either for development only, manufacturing only or from development through manufacturing and maintenance (**Fig. 3**). We also provide customers with IPs and/or software (**Fig. 4**).

### 2.3 Consulting and Training Services

For the various issues that affect the product development of customers, we propose ideal solutions based on NEC's

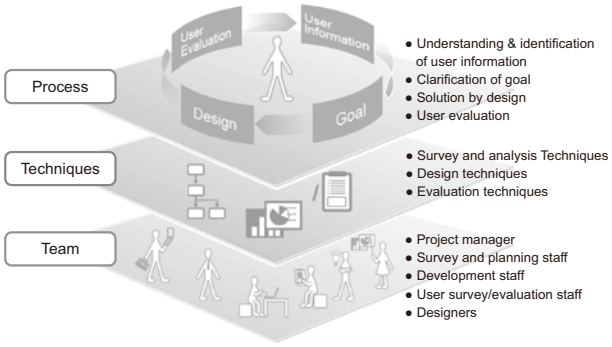


Fig. 5 Human-centered design consulting for HDC (UCD)

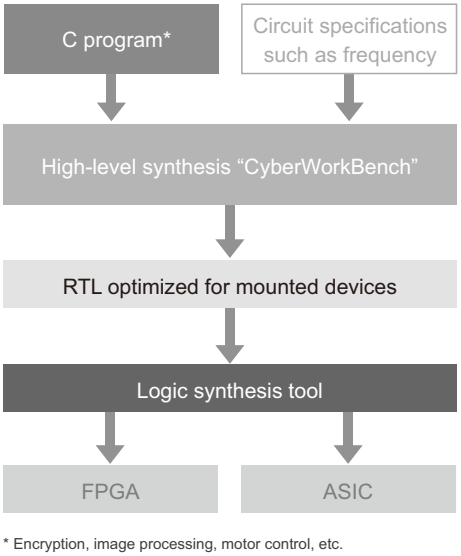


Fig. 6 Automatic synthesis of C program algorithm processing to FPGA.

achievements and expertise (**Fig. 5**). We also contribute to fostering human resources.

### 2.4 Development Tools, Development Support Services

We provide development tools contributing to quality improvement and cost reduction (**Fig. 6**) as well as the development support services of our professional staff.

## 3. The Importance of FPGA Design in the Age of IoT

The FPGA (Field Programmable Gate Array), an example of which is introduced below, is currently attracting attention as another type of computing device. In the IoT age, everything is connected to the Internet including the component parts flowing through the factory production systems and manufacturing lines and the sensors that measure the humidity and temperature in the factory. When, for example, there is a need

for machines to reorganize production lines by themselves without human intervention according to the inventory volume, the FPGA will enable flexible, real-time reorganization of the production line in order to adjust the production quantity automatically.

Unlike ASIC, which is the custom LSI, the ASSP that is the standard LSI and other logic LSIs such as microprocessors, the FPGA features the capability of free programming of electronic circuitry. Although this peculiar feature makes FPGA suitable for electronic equipment development despite the constraints of complication, increase in scale, increase in costs and decrease of product life, its use is generally affected by the problem of low design productivity. As the logic design (programming) of the FPGA must be performed with the help of hardware using a dedicated hardware description language such as the Verilog-HDL or VHDL, a hardware designer needs to take a few weeks or even several months over the work.

An effective solution for this problem is the CyberWorkBench developed by NEC. The CyberWorkBench is a design tool that allows the FPGA logic design (programming) to be performed using the C language, which is one of the most popular languages used by software designers to describe algorithms. Its auto synthesis technology enables FPGA design in a short period with high flexibility.

## 4. Modular and Integral architectures of Embedded Software

The basic requirements for the development of embedded software include: real-time capability, high reliability/stability, observable resource restrictions including for memory capacity and processor performance, and a high degree of excellence. On the other hand, considering the advancement of embedded systems and the complications of the rapidly burgeoning software, it is required to build a development process that can quickly reflect various needs. These include a reduced development term, quality improvement and cost reduction (e.g. via off-shore outsourcing), as well as being capable of meeting the increasing needs of quality improvement and cost reduction. Since the products and services of customers are also affected by global cost competition, we should aim particularly at providing high added values to our developments.

The embedded software development consists of developing parts (or whole in some cases) of the software controlling the embedded system for the customer, so that the coordination ("integral architecture") of the development allotment for the customer becomes a critical matter. Moreover, another critical point of efficient software development is to modularize the software in order to enable reutilization and to combine modules in an optimum manner ("modular architecture") (**Fig. 7**).

- Integral architecture: When the interface between modules cannot be determined, it is required to gather the modules together and to fine tune them.

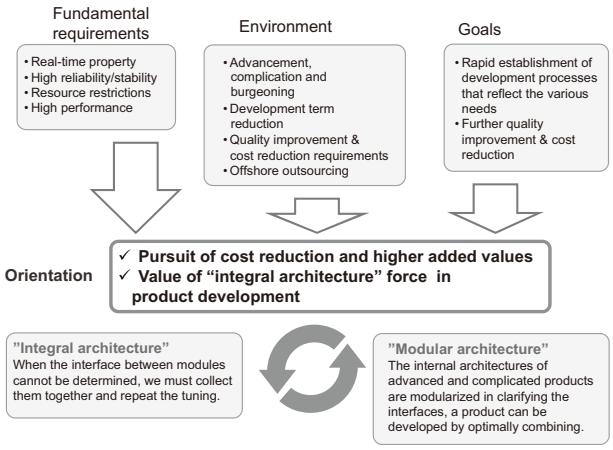


Fig. 7 Promotion of embedded software business.

- Modular architecture: The internal architecture of an advanced and complicated product is modularized. As the interface is clearly defined, the product can be developed by combining optimum modules.

When starting up service businesses in the age of IoT, the need is increasing that the customers themselves configure and verify the entire service based on the idea of the Lean Startup. In order to meet this need, it is necessary to select and implement the required functions by considering hardware and software components over a wider range than before. This makes it important for the embedded software to adopt advanced modularization with full consideration of the size, functionality and maintainability.

For example, with the transmission/reception of sensor data and that of the cloud system via the network, sophisticated modularization is required by defining the interfaces while considering the advancement of adjacent function blocks. With the data analysis, too, function allotment based on "integral architecture" considers that response rates and network environments are required. For example, by allocating some functions not only to the could system but also to the embedded software, the real-time performance can be ensured. At NEC, we respond to customer needs via the modular combination and fine tuning technologies based on expertise acquired via the NEC's C&C concept.

## 5. Conclusion

At NEC, we consider that embedding technologies and solutions are the starting point for visualization in the form of digital data, their analyses & inferences and the feedback of results for use in their control & guidance. By repeating this cycle via demonstration trials, we will pursue added value for the age of IoT and create new business models in collaboration with customers and partners (**Fig. 8**).

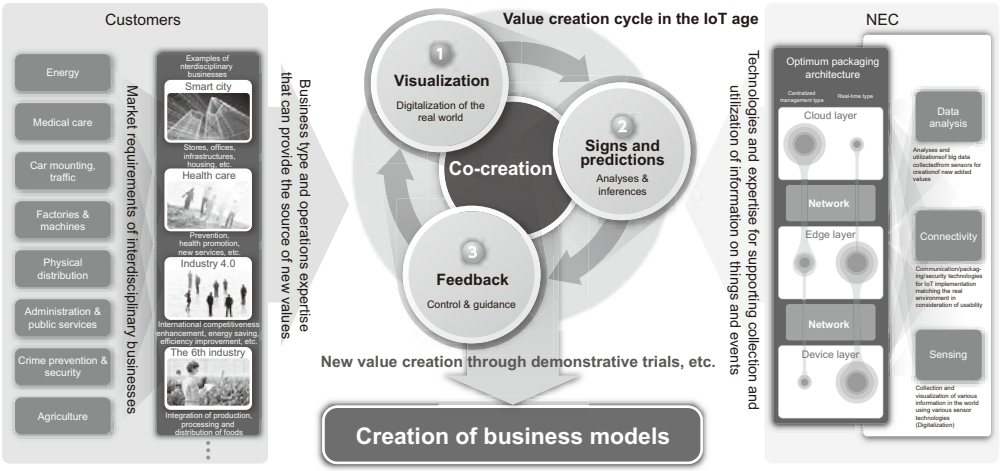


Fig. 8 Value creation cycle.

Embedding technologies and solutions will direct society to the world that achieves safety, security, efficiency and equality. We aim to employ these technologies to connect the real world to ICT with the aim of helping to solve problematic social issues.

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