# Fujitsu Laboratories Global Activities

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*(Manuscript received May 28, 2009)*

**Fujitsu Laboratories has established three laboratories in the USA, China, and Europe and has been building a global R&D system. Each overseas laboratory is developing technologies utilizing the region's characteristics and working with local universities and research institutes. The activities that have taken root in the region were promoted in order to start up R&D functions at the initial establishment. Since 2005, R&D management has been shifted to focus on outputs more strongly in harmony with all laboratories worldwide and on open innovation. Overseas laboratories have established deep relationships with the local communities and benefit from the outstanding environments and talents in those regions. They are carrying out R&D and business incubations and producing remarkable outputs.**

## 1. Introduction

Fujitsu Laboratories has established three overseas research facilities to build a global system for promoting research and development: Fujitsu Laboratories of America, Fujitsu Research and Development Center (China), and Fujitsu Laboratories of Europe. These facilities conduct research in close cooperation with local universities and research organizations, including work on technology related to the characteristics of each local region.

In the beginning, research activities intended to bring out originality were conducted with the objective of raising the research capability of each laboratory. Since 2005, the research management has been strengthened to create a stronger awareness of the output from global cooperation, and the laboratories have taken on the challenge of R&D by setting their own research strategies and topics. By taking advantage of the excellent local environments and talent, they have come to play an important role in supporting the leading edge of Fujitsu Laboratories R&D.

## 2. Fujitsu Laboratories of America (FLA)

Fujitsu Laboratories of America (FLA)[1] was established in California's Silicon Valley in 1993 as the advance team for global development by Fujitsu Laboratories. Later, new research facilities were set up in College Park, Maryland and in Richardson, Texas, and they all proceeded with development activities. The primary mission of FLA involves the following goals.

- Take advantage of excellent local talent to develop differentiating technology.
- Cooperate with excellent North American research organizations to rapidly develop outstanding technology through open innovation.
- Cooperate with the Fujitsu office in North America to contribute to business development.
- Participate in standardization activities to increase Fujitsu's influence in the process.

- Construct a new model for converting research into business results through cooperation with venture enterprises and investors.

To fulfill this mission, FLA applies the "Networked and Open Laboratory" concept, and each of the Fujitsu and Fujitsu Laboratories facilities is undertaking new R&D through cooperation with North American research organizations and enterprises. The laboratories are creating leading-edge technology in server interconnection, Internet services, Internet protocol (IP) networks, LSI design technology, and other such fields. They are also studying technology trends in North America, standardization activities, and the process of converting research results into business development.

## 2.1 In the beginning: Research on LSI design technology

When FLA was first established, LSI design technology was set as a research topic, being an important aspect of the manufacture of Fujitsu products. In addition to a staff of ten persons who mostly had doctorates, there were three advisors who were well known experts in this field: Professor Bryant of Carnegie Mellon University and Professors Brayton and Sangiovanni-Vincentelli of the University of California, Berkley.

Over the following ten years, research results accumulated and FLA attained a world-class level of research in logical function processing technology, circuit logical equivalence testing technology, and model validation technology, etc., greatly contributing to improvements in Fujitsu LSI design technology. In particular, the equivalence testing technology produced the ASSURE tool, which was provided to Fujitsu and its customers and has long been used as an essential tool in LSI development. FLA also received licensing income from the top vendors in the field of design technology.[2] The various types of developed technology are maintained even now at a world top level and they are being used in Internet search technology and Web application testing technology as well as in LSI design technology.

Of the many projects conducted in collaboration with North American research organizations, the Bounded Model Checking technology developed together with Professor Clarke of Carnegie Mellon University is currently being used as an important technology in LSI verification and software verification. Professor Clarke received the Turing Award in 2007, at which time he recognized FLA with the words, "I would like to thank FLA for their contributions. The many results of our joint research have been highly fruitful in terms of both advancement of technology and application in business."

## 2.2 FLA 2.0: Networked and Open Laboratory

In 2006, the overall structure of FLA was reformed on the basis of the concept of the "Networked and Open Laboratory" as "FLA 2.0". The laboratories took up the challenge of moving forward with leading-edge R&D in the North American R&D network, actively adopting outside technology, and presenting the results openly outside Fujitsu. Along with this reformation, the research subjects that had steadily expanded were reconsidered and five research areas were identified. Three groups and one center aim to achieve innovation in the fields of servers, networks, and services, which are important business fields for Fujitsu at present and in the future. Another group aims to identify new trends in North America and develop new processes for linking research results to businesses. Activities in these areas are introduced below.

### *2.2.1 Platform technology*

The Component and Device Innovation Group develops differentiating technology for the

servers that Fujitsu develops, including world-class research results in analog circuit design technology, high-speed input/output technology, and board mounting technology. Working together with Fujitsu Laboratories, it developed a multichannel high-speed transceiver circuit[3] for implementing a high-speed blade server and a complementary metal oxide semiconductor transmitter IC[4] for a 40-Gb/s optical transmission system that were announced in February 2009.

Future work will focus on developing technology for servers that are more energy efficient and for reducing power consumption by equipment interconnections, which accounts for a considerable part of the energy consumed in data centers. The research also includes next-generation interconnection technology, of which optical interconnection is representative.

### 2.2.2 Trusted systems

The Trusted Systems Innovation Group is developing technology for constructing information technology (IT) systems that are secure and reliable for the user. Reliability requires technology for both guaranteeing the security, integrity, and reliability of the overall IT system and all of its components and for ensuring early detection of external attacks or other such problems and providing countermeasures against them.

The Web application verification and testing technology based on the model checking technology developed into tools by FLA has proven effective through applications under development by Fujitsu.[5] Progress has also been made in technology for preserving data removed from the system and in the development of end-point security. A secure universal serial bus (USB) memory device that implements an automatic data deletion function was developed in April 2009, allowing secure management of confidential information and preventing data leaks, even if data is lost or stolen.[6] The vigorous activities of the Trusted Computing Group, an industrial standardization organization, also increase the presence of Fujitsu in the standardization process.

### 2.2.3 Internet services

The Connected Information Innovation Center uses advanced technology for natural language processing and signal processing to develop technology for analyzing and understanding interrelationships among the various types of data that exist on the Internet and creating a variety of Internet services. It has applied new algorithms for large-scale natural language processing and developed technology for automatically generating domain-independent ontologies. That technology serves as a base for the development of various new Internet services, such as the Xurch Cloud search support environment that was announced in June 2009.[7]

### 2.2.4 Network systems research

City and regional networks are expanding dramatically through integrated Internet connection, IP telephony, video services, and interactive services such as Ethernet services, games, and videoconferencing. To provide the bandwidth required by these services, service providers are rapidly developing reconfigurable optical add/drop multiplexers for optical communication networks. The Network Systems Innovation Group possesses front-running technology in optical communication systems, particularly optical modules, optical nodes, optical communication systems, next-generation communication systems, and network management systems. It works closely with Fujitsu Network Communications and is playing a major role in promoting the company's business.

### 2.2.5 Marketing and business innovation

The Marketing and Business Innovation Group surveys and researches the technology markets and technical trends in fields where

North America leads, such as mobile services, IT support for healthcare, and social media. It provides information that is indispensable for Fujitsu's technology development strategy and supports business expansion based on the advanced technology developed by Fujitsu Laboratories through open innovation, with particular consideration given to spin-offs and licensing. It also holds annual exhibitions that introduce technology to venture capital firms, start-up companies, universities, consultants, and research organizations. Introducing and discussing laboratory technology creates a base for expanding the power of open innovation.

## 3. Fujitsu Research and Development Center (FRDC)

Since the Fujitsu R&D Center (FRDC)[8] was established in Beijing in 1998, the fundamental capability of the facility has grown through joint R&D with Fujitsu Laboratories. That capability will serve as a base for promoting independent R&D that can develop a global market for China in the future. The research topics are communication and information processing, microdevices, and fields of study that combine them. This section describes the present and future work of FRDC in the context of the present and future of China.

### 3.1 Significance of China

From the initial 11 researchers, the staff has grown to 80 researchers who are engaged in leading-edge R&D in Beijing and Shanghai. The number of researchers has increased in line with China's expanding economy (**Figure 1**).

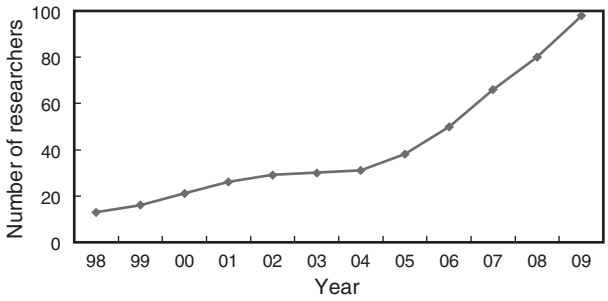



Figure 1
Trend in number of researchers.

The current research topics cover a wide range that extends from communications (wireless and optical communications) to information processing (Web information processing, natural language processing, and media recognition) and microdevices (image and audio compression and encoding). The initial priority for promoting R&D in China was cost performance, but this has since diversified for three reasons. First, China has steadily been transforming from a place for manufacturing facilities to a place for R&D facilities, and science parks and other R&D infrastructure are rapidly being established. The second point is the excellent talent that is available. China has about ten times the population of Japan, and the students who succeed in the severely competitive environment are both highly capable and highly interested in IT. The third point is the immense size of the Chinese market. R&D on products suitable for the Chinese market requires local research laboratories staffed mainly by local researchers and business discussions with customers in collaboration with local business entities. China has adopted many independent industrial standards, and early participation in the establishment of industrial standards is necessary. An overview of the Chinese market is given below.

### 3.2 Chinese IT market

China's gross domestic product ranked fourth in the world in 2007. Automobile sales in China were the world's highest in 2008. Measures valued at approximately US$ 645 billion were taken against the current financial crisis. Here, we describe a few topics concerning China's IT industry.

#### *3.2.1 Cell phone market*

The cell phone market in China has

expanded dramatically since 2000, and there are currently 650 million users (of GSM [global system for mobile communications] and CDMA [code division multiple access]). Even though worldwide demand is shrinking, the expansion trend in China will continue and is expected to reach 820 million users by 2010 (GSM and 3G [third generation]). In January 2009, 3G cell phone licenses were finally granted to the three major carriers: China Mobile (for TD-SCDMA [time division synchronous CDMA]), China Unicom (for W-CDMA [wideband CDMA]), and China Telecom (for CDMA2000). Partial services began in June 2009.

#### 3.2.2 Internet market

In June 2008, China's Internet population became the largest in the world. In 2009, the number of users reached 300 million, of which 70% were less than 30 years old. Usage data reveals that online gaming over the Web has developed into a major business. The search company BAIDU, the consumer-to-consumer electronics business TAOBAO, and other such companies have begun to develop worldwide business as well as domestic business. BAIDU in particular entered the Japanese market in 2007 with a Japanese search service that is steadily maturing.

#### 3.2.3 Semiconductor market

The semiconductor market in China has achieved rapid growth over the past several years, but sales are expected to decline by about 5.8% in 2009 relative to the previous year. There is, however, promise for growth to turn positive again in 2010, followed by broad growth over the long term. Other factors such as the transition of cell phones to 3G, the shift of TV from analog to digital in 2015, and the great increase in the Internet population and numbers of private automobiles all make the predicted growth in China's domestic market for electronic information products much higher than the worldwide average. That growth is expected to serve as a driving force for the future worldwide semiconductor market.

### 3.3 Chinese industrial standards

The Chinese government is moving forward with active globalization of domestic industrial standards to stimulate the country's industry, particularly in the fields of telecommunications and multimedia. Dealing with Chinese industrial standards is essential to success in Chinese business. Some key industrial standards issued in China are outlined below.

#### 3.3.1 Cell phones

China has developed the TD-SCDMA scheme as its national strategy for 3G standardization. This is a member of the 3G family formally standardized by the International Telecommunication Union (ITU) in 2000. The application of time division duplexing (TDD) in the development of standards to follow 3G, e.g., Long Term Evolution (LTE) and IMT-Advanced, is also being promoted at the national level, and there are activities to merge the frequency division duplexing (FDD) scheme and the TDD scheme.

#### 3.3.2 Digital broadcasting

Concerning modulation-demodulation schemes for terrestrial digital TV broadcasting, the schemes devised by Tsinghua University and Shanghai Jiao Tong University were merged in August 2006 and enacted as National Standard (GB20600-2006). The Chinese industrial standard China Mobile Multimedia Broadcasting GY/T220 standard promoted by the State Administration of Radio, Film and Television is currently in effect for TV broadcasting for mobile devices; it corresponds to the one-seg service in Japan.

#### 3.3.3 Image compression technology

The GB/T20090.2-2006 audio and video

coding standard (AVS), which has performance on par with H.264, is in effect as a national recommended standard and has been adopted for terrestrial digital TV broadcasting in Shanghai and Hangzhou among other places and for the Internet protocol television (IPTV) services of China Unicom. Although independent industrial standards are used to protect China's domestic market, it is highly likely that Chinese industrial standards will become global standards in the future. FRDC will also continue to contribute to the establishment of these Chinese industrial standards.

## 3.4 FRDC: R&D overview

Considering China's market and industrial standards, as described above, the telecommunications, information processing, and microdevice laboratories of FRDC are currently conducting R&D on the following three topics.

### 3.4.1 Telecommunications

R&D of physical layer signal processing technology is proceeding for the two fields of wireless communications and communications for next-generation communication systems.[9] In both these fields, the focus is on the digital signal processor for received signals shown in **Figure 2**. In the future, we plan to expand into communication fields other than telecommunications, with physical layer signal processing technology serving as a basis for building an R&D group to cultivate the market in China.

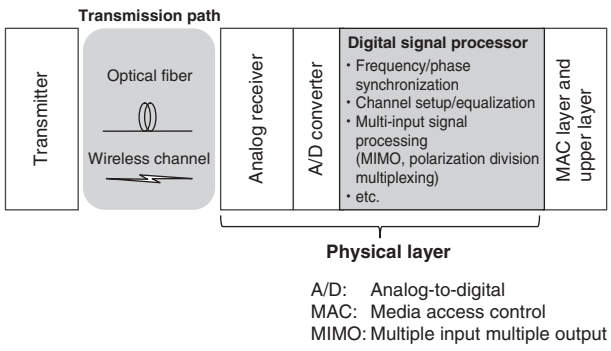



Figure 2
Digital signal processing.

### 3.4.2 Information processing

R&D oriented to developing business both in China and globally is being conducted, focusing on Chinese language and media processing technology. Examples of research results that contribute to business development include the Chinese language analysis technology and character recognition technology, which have generated business in China.

The Chinese language analysis technology[10] can perform real-time analysis of ten million weblogs and other Web pages and discover powerful influences. This technology promises to serve in monitoring for slander concerning labor conditions for local companies in China and environmental problems as well as monitoring for defamation of Japanese company managers and brand infringements. In June 2008, Fujitsu implemented China's first content service.

Concerning character recognition technology[11] on the other hand, form recognition technology was developed to handle Chinese forms that have features specific to Chinese and contain noise such as stamps or poor-quality printed characters. In October 2006, negotiations were held with the Chinese government on a nationwide agricultural survey and with major banks. Future work will be aimed at the use of global information and fusion of different types of elemental global media recognition technology as well as continuing with R&D that corresponds to various business models that extend from solutions to software as a service (SaaS) and Cloud services.

### 3.4.3 Microdevices

R&D is being conducted on system LSI devices for audio and video systems (**Figure 3**). So far, a high-definition (HD) video decoder LSI that can handle multiple standards, including

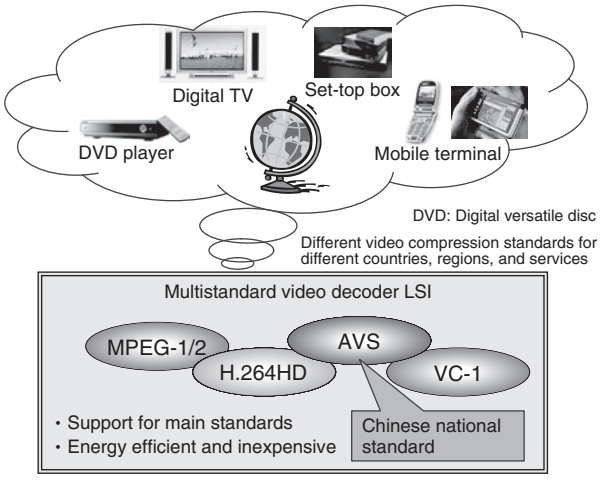



Figure 3
Multistandard video decoder LSI.

the China standard AVS, an energy-efficient down-decoder LSI, graphics display controller LSI for car navigation systems, a full-HD multi-decoder LSI that is compatible with both MPEG-1/2 and H.264, and other such devices have been developed in collaboration with Fujitsu and Fujitsu Laboratories.[12] Development of a video decoder and an audio decoder in collaboration with Fujitsu Microelectronics, Ltd. (Shanghai) is also in progress. R&D that is more focused on the Chinese market is also moving forward.

### 3.5 Cultural activities

Various cultural activities are supported to deepen cultural exchange between China and Japan. Every year, the group co-presides over a Go (Weiqi) tournament for college students and many students from universities all over China and Japan participate in this two-day event. Since 2000, the group has also been participating in tree-planting activities organized by the Beijing Investment Promotion Bureau to strengthen friendly relations with the region. Other activities included donating tuition and school supplies for grade school students in Bai Yang, Hebei Province in 2006.

## 4. Fujitsu Laboratories of Europe (FLE)

Fujitsu Laboratories of Europe (FLE)[13] was established in a suburb of London, UK in 2001 to perform R&D that takes advantage of the excellent researchers, expertise, public investment, and other abundant resources available in Europe. Two-thirds of the researchers have doctorates in their fields, and R&D is conducted in a global environment with members from countries around the world.

### 4.1 R&D overview

There are three main R&D areas.

- Next-generation services
- Next-generation networks
- Next-generation technical computing

This R&D is currently being done by the Services & Solutions, Network Systems, and Environment & Health Research Divisions. FLE also works towards strategic cooperation with industry, academia, and governments and towards open innovation through the EU Project, joint research with advanced research organizations, and commissioned university research.

#### *4.1.1 Next-generation services*

FLE has been active in grid computing standardization, particularly by playing a central role specifying the next-generation architecture Open Grid Services Architecture (OGSA) in the Open Grid Forum, an international standardization organization for grid technology.[14] Fujitsu's Unified System Management Technology (**Figure 4**), which conforms to OGSA, has been adopted as the data cooperation platform for the EU ADMIRE project[15] on distributed data mining. That project targets many distributed resources of different kinds and is currently being extended to data centers, which are the main providers of IT services.

In cooperation with the Carbon Trust and

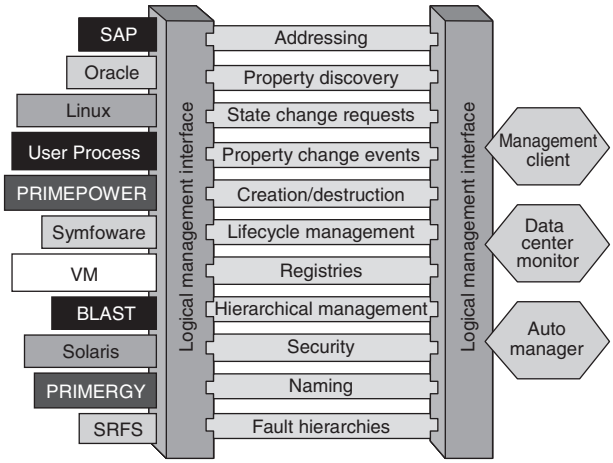
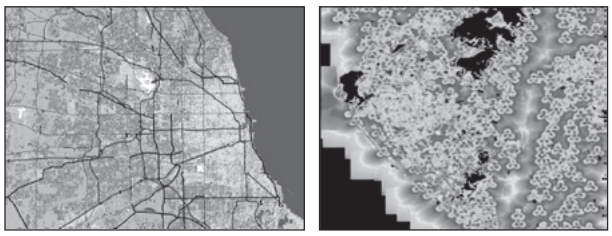



Figure 4
Unified System Management Technology.



(a) Chicago planning (b) Taipei planning

Figure 5
Example of network design using radio network dimensioning tool DoORs.

the British Computer Society, FLE is working on optimization using data center simulators. Those simulations involve all the elements of a data center, including the power supply and air conditioning, equipment arrangement, as well as the computers operating in the centers. This comprehensive modeling makes it possible to optimize the data center with respect to environmental load factors such as $CO_2$ emissions and energy consumption.

Other research subjects include discovery technology for accurate determination of resource conditions in data centers that use advanced virtualization, data center symptom technology for problem diagnosis and recovery, and service development technology for the platform as a service (PaaS).

### *4.1.2 Next-generation networks*

In telecommunications standardization, FLE has recently participated in standardization activities for WiMAX (Worldwide Interoperability for Microwave Access), LTE, and LTE Advanced, creating important intellectual property rights and leading in the development of Relay System Profile Requirements for WiMAX (for which it received the 2008 WiMAX Forum Leadership Award). Other developments in this area include the DoORs network design tool for wireless broadband access (**Figure 5**), which supports development of the Fujitsu BroadOne WX300 base station, thus reinforcing WiMAX and LTE business in the markets of North America and of Europe, the Middle East, and Africa.

As we progress into an aging society with a falling birth rate, expectations for services that provide social support for elderly people are increasing in Europe. R&D on services such as remote healthcare and other such systems for supporting the daily life of persons afflicted with long-term chronic diseases is particularly prevalent. FLE is performing R&D on a services platform for providing the network services required for remote healthcare and other forms of social care. It is also performing R&D to clarify advanced use cases and increasing the reliability of network services in support of Fujitsu Services' healthcare project in the Netherlands.

Concerning standardization, which will be important in the future, FLE is also putting effort into research on wireless body area networks, targeting medicine and sensor networks, and on autonomous networks for the future Internet (by participating in planning for the EU EFIPSANS project).[16] As an aspect of open innovation, FLE is participating in the planning of the digital communications knowledge transfer network[17] by the UK government's Technology Strategy Board and contributing as a board member.

In fields other than standardization, FLE

is working toward "green wireless". For typical cellular network operators, about 80% of all $CO_2$ emissions are from energy used for operating the network. In the era of wireless broadband telecommunications, energy conservation and $CO_2$ emissions reductions are now major issues. If the demand for higher data transfer volumes (which has roughly doubled over the last two years) continues, it will be necessary to decrease the energy cost per bit by at least the same factor. FLE is developing technology to reduce energy consumption per bit to 1/100th the present value.

#### *4.1.3 Next-generation technical computing*

FLE is performing R&D on software for next-generation high-performance computing (HPC), making use of researcher competence in HPC, large-scale simulations, and other computations for the fields of medicine and the environment, which are important future topics, as well as computer-aided engineering and other fields that are in strong demand by customers. Themes that require specialized knowledge in fields such as simulation models are developed through joint research with universities, and FLE is focusing on developing libraries that draw out the potential capabilities of the HPC platform. For the heart simulation (**Figure 6**) being undertaken by the EU preDiCT project,[18),19)] for example, the target is to increase the simulation speed by a factor of at least 10 000 and achieve real-time simulation in collaboration with Oxford University and other such organizations. For the environment, FLE is working with Imperial College London on ocean simulations related to climate change (**Figure 7**).

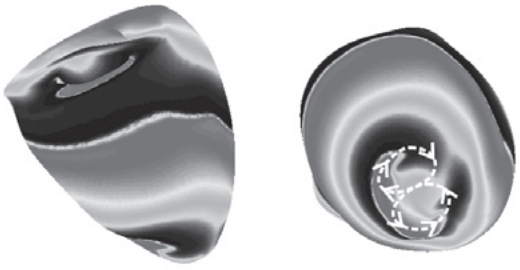
While these simulations are significant in themselves for solving important problems in medicine and environmental science, the developed technology is intended to play a wider role as core software technology for the next generation of technical computing.

### 4.2 Activities undertaken as European R&D facilities

FLE cooperates with Fujitsu Services (UK) and Fujitsu Technology Solutions (Germany) and other branch companies and utilizes the research results of Japanese and other overseas laboratories as well as its own research results. As part of its technology marketing activities, FLE holds a European Technology Forum every year to promote the latest laboratory technology to European branch companies and customers directly and to collect customer requirements, create business opportunities, and promote technology incubation.

## 5. Conclusion

The three overseas offices in the USA, China, and Europe take advantage of close



Source: Oxford University

Figure 6
Study of spiral electrical waves in a heart.

Source: Imperial College London

Figure 7
Ocean simulation in the North Atlantic.

cooperative relations with local universities and research organizations and the excellent local environments and talent as well as the special characteristics of these regions to produce remarkable results through R&D and business incubation. In the future, they will all continue developing leading-edge technology as global research laboratories.

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