The Story of the Internet of Things: A Postprint Written on the 40th Anniversary of the "Spring of Science"

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Abstract

Full Text

The Story of IoT—Written on the "Spring of Science"

The "Spring of Science" Paved My Research Path

We are an extraordinarily fortunate generation in the history of the People's Republic. As we came of age, we encountered the favorable era of setting things right following the Cultural Revolution. Several pivotal decisions made by the Central Government in 1977–1978 paved the way for our lifelong development.

In 1977, China's college entrance examination system, suspended for a decade due to the Cultural Revolution, was restored, heralding a springtime of respect for knowledge and talent. On March 18, 1978, the National Science Conference was convened post-Cultural Revolution, where Deng Xiaoping put forward the famous theses that "science and technology are productive forces" and "intellectuals are part of the proletariat," delivering both a "spring of science" and a "spring for intellectuals." On June 23, 1978, while listening to the Ministry of Education's work report on Tsinghua University, Comrade Deng Xiaoping issued important instructions on expanding the dispatch of students abroad: "I favor increasing the number of students sent abroad, focusing mainly on natural sciences," "We should send thousands upon thousands, not just ten or eight," and "We must accelerate the pace by all possible means, widening the path as we go." This opened the prelude to large-scale overseas study in the new era, turning a new page in China's study-abroad work.

As fortunate beneficiaries of this era, I entered Wuhan University in 1979 through the college entrance examination to receive formal university education. In 1986, I passed the graduate entrance examination and was sent to France for doctoral studies at public expense. After completing my master's (DEA),

doctoral studies, and two years of postdoctoral research training in France, I returned to China in 1992 to join the Institute of Semiconductors at the Chinese Academy of Sciences (CAS), dedicating myself to scientific research. Under organizational arrangements, I transferred in 2001 to the Shanghai Institute of Metallurgy at CAS (later renamed the Shanghai Institute of Microsystem and Information Technology), and in 2009, I began preparations for establishing the Shanghai Advanced Research Institute of CAS. Looking back on my journey from entering university in 1979, studying abroad in 1986, returning to work at CAS in 1992, and serving at three research institutes while participating in the "Knowledge Innovation Program" and the "Pioneer Initiative," although I have achieved modest accomplishments in research and management, all these successes must be attributed to the Central Party Committee's restoration of the college entrance examination, the creation of an environment that respects knowledge and talent, the policy of large-scale overseas student dispatch, and the strategies of revitalizing the nation through science and education and strengthening the nation through science and technology.

Fortunate Participation in Wireless Sensor Network and IoT Research

Due to national development needs, many in our generation assumed important scientific research and leadership positions at a relatively early stage, making positive contributions to the nation's scientific and technological endeavors. My involvement in wireless sensor network (WSN)/Internet of Things (IoT) research serves as one such example.

In 1999, an international conference on mobile computing and networking in the United States identified wireless sensor networks as another development opportunity facing humanity in the 21st century. I had the privilege of participating in the compilation of CAS's 1999 strategic research report, *Pilot Directions for the Knowledge Innovation Program—Research Report on Information and Automation Fields*, which recommended wireless sensor network technology as one of six major projects in the information domain. In 2003, *MIT Technology Review* ranked wireless sensor network technology as the top among ten technologies that would change people's lives.

In 2001, then CAS Vice President Jiang Mianheng advocated for and personally chaired the establishment of the CAS Microsystem Technology Research and Development Center (referred to as the "CAS Microsystem Center"). He transferred me from the Beijing Institute of Semiconductors to the Shanghai Institute of Metallurgy to serve as director of the CAS Microsystem Center, organizing relevant CAS institutes to pioneer large-scale research in sensor networks and microsystems. Although international WSN research had become a hot topic and leadership attached great importance to it, project approval was not smooth sailing. The research team frequently worked through the night discussing and preparing proposals, yet for nearly two years, the plan failed to gain approval from the CAS review expert panel multiple times. In the final evalua-

tion, the team further refined the technical route according to expert opinions, while an authority from the user department introduced the status of domestic equipment, fully affirming our proposal and stating that the CAS Microsystem Center's plan would bring a "qualitative" leap to China's relevant equipment. From that point, the system project was officially approved and launched.

WSN Research Achievements Safeguard National Security

Thanks to the rigorous requirements of CAS leadership and experts, my research team, after several years of diligent work, developed a uniquely technical and high-level wireless sensor network system. In 2008, we successfully completed China's first WSN application system—the "Pudong Airport Anti-Intrusion Sensor Network Pilot Project"—which passed acceptance in April that same year. The Shanghai public safety sensor network platform we developed was successfully applied to the 2008 Beijing Olympic torch relay in the Shanghai, Ningbo, and Jiaxing sections, as well as in security operations for the Shanghai Cooperation Organization Six-Nation Summit and the International Special Olympics, where it protected heads of state.

Earthquake Response and Emergency Communications

When the Wenchuan earthquake struck in 2008, communication equipment was destroyed and information flow was almost completely interrupted. Our first thought was to use the MiWAVE broadband wireless communication technology, independently developed by our institute (the Shanghai Institute of Microsystem and Information Technology, CAS), to urgently solve this problem. This broadband wireless communication system features large bandwidth, flexible deployment, and strong adaptability, enabling wireless connection with mobile networks, the internet, or satellites to transmit voice, images, video, data, and other information in real time, providing urgently needed communication support for disaster areas with severely damaged infrastructure.

On the evening of May 13, I convened relevant scientific and technical personnel to discuss and demonstrate the feasibility of applying the broadband wireless communication system to earthquake relief. On the morning of May 14, I chaired an emergency director's office meeting: the Microsystem Institute established an earthquake relief leadership group with me as head; it decided to allocate special earthquake relief funds, purchase relevant rescue equipment, and actively participate in relief efforts using the broadband wireless communication system. On the evening of May 16, the first emergency communication rescue team from the Microsystem Institute departed for the Sichuan earthquake disaster area. They pioneered the establishment of a broadband wireless communication network in Beichuan County, opening information channels for the disaster area. On May 18, the rescue team erected a second system in Yong'an Town, An County, establishing the town's first post-disaster video and data link with the outside world. On May 24, they rapidly deployed broadband wireless communication networks in Guanzhuang Town, Qingchuan County, and Nanba

Town, Pingwu County, deep in the mountains, enabling real-time monitoring and command from the rear headquarters to the frontlines of earthquake relief in these locations.

The Tangjiashan barrier lake, less than 100 kilometers from Mianyang with a water storage capacity exceeding 200 million cubic meters, was described as a "sword hanging over the heads" of Mianyang's more than one million people, posing a severe threat to lives and property. On the evening of May 30, I led a 17-person team with essential equipment to Tangjiashan. After several days of continuous installation and debugging, we established a remote broadband wireless monitoring system. Through 14 monitoring points deployed in front of and behind the Tangjiashan barrier lake dam and along the lake-to-Mianyang route, we monitored hydrological data and dam changes 24 hours a day. With Vice President Jiang Mianheng's strong promotion and coordination, the video monitoring images were transmitted in real time not only to the command center in Mianyang but also provided over 50 remote monitoring video streams to national and relevant provincial and ministerial leaders, supplying real-time video data for managing the Tangjiashan barrier lake crisis.

Honors from WSN and the Birth of the IoT Industry

In 2008, the project "Wireless Sensor Networks and Their Application in National Security" led by me at the Shanghai Institute of Microsystem and Information Technology, CAS, won the first prize of the Shanghai Science and Technology Progress Award. For outstanding performance in earthquake relief, I was awarded the honorary title of "National Model for Earthquake Relief" by the Central Committee of the Communist Party of China, the State Council, and the Central Military Commission—the only such recipient from CAS.

On the afternoon of August 7, 2009, then Premier Minister Wen Jiabao inspected the CAS Wuxi Micro-Nano Sensor Network Engineering Technology R&D Center. After listening to the report, he immediately stated: "When the computer and internet industries developed on a large scale, we took some detours because we did not master core technologies. In the development of the Internet of Things, we must plan for the future earlier and break through core technologies sooner." He also instructed: "At least three things can be done quickly: first, integrate sensor systems with TD technology in 3G; second, accelerate the development of sensor networks in major national science and technology projects; and third, rapidly establish China's sensor network center (base), or what could be called the 'Sensing China' center (base), amid fierce competition or pressing circumstances."

Following Premier Wen Jiabao's Wuxi speech, wireless sensor networks were officially renamed as the broader concept of IoT at the national level. CAS research work received high attention from all parties, leading China's IoT research and giving birth to IoT as a strategic emerging industry.

Serving the Country, Moving Forward Continuously

In 2008, CAS hoped to serve the main battlefield of the national economy through institutional and mechanism innovation, and decided to cooperate with Shanghai to establish the Shanghai Advanced Research Institute of CAS to promote the development of strategic emerging industries in Shanghai. In 2009, four senior institute directors, including myself, were assembled to begin preparations for the institute. In 2012, the institute officially completed its establishment and entered the formal CAS institute sequence. Over the years, the Shanghai Advanced Research Institute of CAS has developed distinctive characteristics and achieved meaningful experience and accomplishments. After my term ended in 2017, I returned to the frontline of scientific research.

The report of the 19th National Congress of the Communist Party of China points out that the Party's historical mission in the new era is to achieve the great rejuvenation of the Chinese nation and to build a comprehensively modern socialist strong country after securing a decisive victory in building a moderately prosperous society in all respects. As scientific and technological workers, we will strive hard and do our part to achieve this goal.

Biography: Researcher at the Shanghai Advanced Research Institute, Chinese Academy of Sciences. Formerly served as Director of the Laboratory and Deputy Director of the Institute of Semiconductors, CAS; Deputy Director and Director of the Shanghai Institute of Microsystem and Information Technology, CAS; Head and Dean of the Preparatory Group for the Shanghai Advanced Research Institute, CAS. Served as an expert for multiple national programs including the "863" Program, Major Scientific Research Plan, and Major Special Projects. Research fields involve low-dimensional semiconductor structures, nanoelectronic devices, wireless sensor networks (IoT), and smart cities. Awards include the CAS Young Scientist Award, CAS Natural Science Award First Class, National Natural Science Award Second Class (second completer), Shanghai Natural Science Peony Award, Shanghai Leading Talent title, "National Model for Earthquake Relief" title, Shanghai "Outstanding Research Institute Director" title, and Shanghai Science and Technology Progress Award First Class.

Note: Figure translations are in progress. See original paper for figures.