CHINESE INDUSTRY 4.0 PATENTS
VOLUME 01

China’s high-impact patents of Industry 4.0 from January 2013 to April 2015

Truong Le | Thomas Fischer
Objectives of the study »Chinese Industry 4.0 Patents«

- Exploring market needs for Sales managers*
- Analyzing IP litigation risks for IP managers*
- Exploring profiles of potential partners for Business developers*
- Competitive analysis for Strategists*

*Based on published patent information
Management Summary – China’s technological strengths and weaknesses in Industry 4.0

Recommendations – Win-win strategies, potential customers for Industry 4.0

Evaluation criteria – Evaluation method of patent documents and applicants

50 high-impact patents – Manual translations and evaluations

Contact

Appendix – More than 1700 Chinese patent abstracts
Management Summary
**Cloud computing:** China announced to develop the "Internet Plus" plan in March 2015. In February of this year, Chinese tech giant Baidu and China Mobile signed a cooperation agreement to jointly build a mobile Internet cloud computing center. In the same month, Lenovo Group reached a deal with Hong Kong Cyberport Management Company to jointly build a cloud service and product research and development center in Hong Kong.¹

According to patent data analysis ZTE and Huawei are the most active players in building up data platforms for Industry 4.0.

**Big Data** is drawing great attention in China. Chinese IT giants like Alibaba, Baidu, Tencent have built up high competencies in Big Data. China’s patents cover all three areas of Big Data: Hardware, Data Mining Software, and industry specific applications e.g. banking, mobility, production automation.

China’s Premier Li Keqiang stated at the first Big Data Expo on May 26th 2015 "China is mulling an action plan to boost big data-based innovation in search of better solutions to government decision-making, transport, medical care and education".²

[2]: http://english.cas.cn/newsroom/china_research/201505/t20150527_147737.shtml
China’s technological strengths in Industry 4.0 (2/2)

**WSNs (wireless sensor networks):** Chinese companies and research organizations have developed intelligent, real-time, energy-efficient, and reliable industrial wireless sensor network technologies to improve existing international standards e.g. IEEE STD 802.15.4-2006. The SIA and the Zhejiang university of technology are excellent research organizations which cooperate closely with local companies and international companies e.g. SAP. \(^3\)

[3]: http://english.sia.cas.cn/ns/pn/201503/t20150326_145745.html

**Low-cost robots:** China is fostering the development of autonomous systems in different areas: military, aerospace, maritime, industry production, agriculture, and cars. In China there are about 400 local robot manufacturers. SIASUN and Foshan Xinpeng Robotics Technology Co. Ltd are important players in China with international activities. \(^4\) The patenting focus of Chinese robot suppliers is currently on low-cost systems (e.g. autonomous mobile robots with simple collision avoidance capability) and connectivity.

China’s technological catch-up in Industry 4.0 (1/2)

Information security: According to security specialists China’s computer-controlled infrastructure is more vulnerable to cyber-attacks than are Western systems.\(^5\) From the patent data analysis the picture is ambivalent. On the one side China is working on high-end encryption technologies e.g. quantum encryption for military and governmental purposes. On the other hand current Chinese patent applications for industrial information security seem to be at basic innovation level. Chinese patents on end-to-end encryption for industrial applications have not been found.

Smart sensors and embedded systems: Small and middle-size Chinese companies are highly active in embedded systems. According to patent data Chinese companies are catching up in this field as local demand for embedded system competencies is very high.

With the political support the next level of technology advancement will be reached.

China’s technological catch-up in Industry 4.0 (2/2)

**Smart robotics:** In many cases there is a need for collaborative robots which does not replace but rather support industrial staff. In this field of robots Chinese patent applications have not been found.

This technology field will be attractive to Chinese robot manufacturers. Chinese research institute CAS has submitted a patent application on a pneumatic robot arm that can handle smoothly production parts.

**Smart applications Industry 4.0:** According to patent data Chinese companies and research organizations have filed a significant number of patent applications on several Industry 4.0 use cases for following industries: beverage, water treatment, coal mines, automotive, general production assembly lines, machine monitoring, etc.

Most of the Chinese inventions on this field are at basic innovation levels.
Current Chinese technology positions in Industry 4.0
Insight through a combined quantitative-qualitative patent analysis

1. Cloud & Big Data
2. Wireless sensor network
3. Low-cost robots
4. Information security
5. Smart sensor & embedded
6. Advanced robots
7. Smart applications

* Based on qualitative analysis of selected patent documents by Fraunhofer experts
Data is available for customer-specific analysis
Patent and economic strengths of each player

Patent families in low-cost robots

* Based on qualitative analysis of selected patent documents by Fraunhofer experts
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Potential customers for international companies

In most segments of medium-innovativeness foreign technologies are needed.

Patent families

1. Cloud & Big Data
2. Wireless sensor network
3. Low-cost robots
4. Information security
5. Smart sensor & embedded
6. Advanced robots
7. Smart applications

China needs foreign technologies

* Based on qualitative analysis of selected patent documents by Fraunhofer experts
Excerpt of potential customers for Industry 4.0 solutions extracted from patent information

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<th>Potential customers of Industry 4.0</th>
<th>Applications</th>
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<td>Beijing Watch Data System Co Ltd</td>
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<td>Tangshan Modern Ind Contr Tech</td>
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<td>Beijing Jingneng Gaoantun Gas Thermal Power Co Ltd</td>
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Analysis approach of the technology study

1. Search terms based on the defined structure for I4.0

2. 2541 priority applications in China (2013.01.01 ~ 2014.04.30)
   - Drop no

3. Select ~1700 patent documents

4. Ranking with two quality criteria (number of inventors, forward citations)

5.1. Selection of 15 patent documents based on automatic ranking

5.2. Manual selection of 35 patent documents (based on a list of most relevant keywords and important players)

6. Translating, summarizing, and evaluating 50 patent documents
Selected patent documents on Cloud Computing & Big Data
Key idea behind the patent:

- M2M means "machine to machine" or "man to machine" communication. To centrally manage M2M devices and applications, a network application creates an M2M group on an M2M platform. The M2M group may be an industry application group, for example, a metering terminal group, a vehicle-mounted device group, or a sensor group. The M2M platform maintains an M2M group definition and controls M2M group services. M2M gateways provide capabilities of connecting for different group members to the M2M platform.

- The communication method: receiving from a network application a group access request that requests access to a group, wherein the group access request comprises a group identifier of the group; obtaining group member information of all group members in the group according to the group identifier; determining, according to the group member information, members of a first group that are connected to a service function entity through a same gateway in the group; and sending, to the gateway, a first group member access request that requests access to the members of the first group.
About Huawei

- Huawei is a leading global information and communications technology (ICT) solutions provider. Huawei has 170,000 employees worldwide and its ICT solutions, products and services are used in more than 170 countries and regions, serving over one-third of the world's population.

- On March 19th 2015 Huawei and NXP Semiconductors decided to jointly explore the Chinese and global Industry 4.0 market at the Industry 4.0 Roundtable held at Hanover CeBIT 2015 Through technical cooperation and joint innovation, the two companies will create an open, robust and secure Industry 4.0 Information and Communication Technology platform.

- Further strategic partners with Huawei on Industry 4.0 are: SAP, Fraunhofer, Hexagon, Microsoft, IBM, and Sobey

- Huawei is one of the world-leading players of the 5G standard which will power the Internet of things.

Sources:
http://www.crn.de/telekommunikation/artikel-105445.html
http://www.ft.com/intl/cms/s/0/2a8d3d8a-ecf3-11e4-a81a-00144feab7de.html#slide0
Selected patent documents on sensor networks and network topologies
Key idea behind the patent:

- EtherCAT module acting as slave station, read data from master station, perform data decryption, therefore obtain data packet which is sent toward instrumentation or electrical equipment under the gateway between EtherCAT industrial ethernet and wireless Zigbee. Central processing module processes data packet to perform packetization or depacketization, then transmitted processed data to Zigbee wireless module. Zigbee wireless module packages packet data into data frame, then transmit to Zigbee wireless devices on instrumentation or electrical devices via air interface.

- Instrumentation or electrical devices sending collected data is the reverse to the above process, which means: Data is collected by instrumentation then sent to Zigbee wireless devices via air interface, then sent to protocol converter devices. Zigbee wireless module in the protocol converter devices then decrypts sent via air interface Zigbee packet, the resolved collected data is then sent to central processing module as cache and being packetized. Afterward, processed data is sent to EtherCAT module. EtherCAT module performs EtherCAT packet packaging and transmits packet to host via ethernet bus.

Image:

Source:
- CN102271100 B

Legal status:
- Patent granted in CN, priority date 20110905

<table>
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<td>Potential for inventing around? [1: yes; 5: no]</td>
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</table>
CN102271100 B: gateway device circuit schematic diagram
Short profile of Guodian Nanjing Automation

- Guodian Nanjing Automation Co., LTD is principally engaged in manufacture and distribution of power automation equipment. The Company distributes its products primarily in domestic market.
- JV with ABB, METSO, ESSI and China XD Group
Some products of GUODIAN NANJING AUTOMATION

Hospital monitoring system
System overview: Medical institute is an important service industry and it has a high requirement on the diversification and specialty of video ...

School monitoring system
System overview: Students are disadvantage groups and the violence events occurring in recent years have raised a new requirement to the secu...

Power monitoring system
System overview: In today's rapid development of economy, the power industry plays a vital role and to guarantee the normal operation of power ...

Urban public safety prevention
System overview: With the construction of modern cities and rapid development of economy of various countries, the city scale is enlarging increa...

Introduction of wind power remote
1. System summary Wind power remote real-time monitoring system is the collection production process real-time monitor...

Introduction of the real-time
1. Overview The real-time monitoring system can improve power production management level, reduce the production co...
About ZTE

- ZTE Corporation is a Chinese multinational telecommunications equipment and systems company headquartered in Shenzhen, China.

- ZTE operates in three business units - Carrier Networks (54%), Terminals (29%), Telecommunication (17%). ZTE's core products are wireless, exchange, access, optical transmission, and data telecommunications gear; mobile phones; and telecommunications software.

- ZTE is investing in digitalization of production lines. CEO of ZTE's terminal product department, according to Shanghai's China Business News, stated: “We will overtake Apple in the smart manufacturing of industry 4.0 in the future”.

- Thanks to automation, productivity at the ZTE factory is 40% higher than traditional production lines and labor costs are nearly 50% lower.

Sources:
http://en.wikipedia.org/wiki/ZTE
Wireless sensor network in mixed mesh and star topology structure

**Key idea behind the patent:**
- A wireless sensor network in mixed mesh and star topology structure.
- The invention uses the superframe structure of IEEE STD 802.15.4-2006 and expand the multi-hop method by removing the need for the node waiting to join the network to be located at the receiving scope of the gateway node.
- The procedure of transmission of long-period data procedure is optimized when not to send data.
- The invention uses a hybrid mechanism comprising frequency division and time division; inter-cycle AFS and intra-cycle frequency hopping technology. It uses fixed channel during one cycle, which increases the network compatibility and it uses both an adaptive frequency switch and frequency hopping technology to improve the network reliability. It uses a hybrid MAC method based on both competition and scheduling.
- A two-stage resource allocation policy comprising a mix of global resource allocation and local resource allocation.

**Patent applicant:** SIA (Shenyang Institute of Automation of the Chinese Academy of Sciences)

**Evaluation by Fraunhofer**

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**Image:**

**Source:**
- CN201099964Y (CN2010)

**Legal status:**
- Granted patent in CN, EP, US, active since 2010

**Technological level of patent applicant:** High
SIA will be a key technology-provider of Industry 4.0

1995 - The first welding robot production line, designed by SIA, was put into use.
1997 - The high performance robot controller with self-owned intellectual property was produced in small batch.
1997 - The first automated robotic press line in China, designed by SIA, was integrated into FAW-Volkswagen automobile production line.
1998 - The first laser-processing robot was developed by SIA.
1998 - SIA-developed pouring robot was first put into production.
2000 - Shenyang SIASUN Robot & Automation Co. Ltd, the first commercial company of SIA was set up.
2010 – The first minimally invasive spinal surgical robot system was developed by SIA.

The preventive maintenance system for industrial equipment, as a result of cooperative research between SIA and SAP for a period of time, mainly integrated WIA-FA industrial wireless network telecommunication technology developed by SIA, equipment preventive maintenance software based on HANA cloud service platform developed by SAP and industrial robot of SIASUN Robot and Automation Co. Ltd. It is capable of sensing the condition information of robot through the construction of internet of things based on wireless telecommunication, thus realizing preventive maintenance of industrial robot by analyzing the data via cloud service platform. The research covers several key technologies of industrial 4.0 such as internet of things and cloud computation, laying foundation for SIA and SAP to jointly realize smart factory based on the concept of industrial 4.0.

- [http://english.sia.cas.cn/ns/pn/201503/t20150326_145745.html](http://english.sia.cas.cn/ns/pn/201503/t20150326_145745.html)
Selected patent documents on low-cost industrial robots
INTELLIGENT MOBILE-WORKING ROBOT

Key idea behind the patent:

- The intelligent mobile robot can automatically get to work, save, send materials, automatic loading and unloading devices without human intervention, to meet the needs of practical work.
- The work of an intelligent mobile robots, characterized by comprising: a moving mechanism (I), fork lifting mechanism (2), take the fork feeding mechanism (3), fork clamp mechanism (4), a grasping mechanism (5), multi-axis robot (6) and the frame body (7), wherein the moving means (I) is mounted on the frame body (7), the drive frame member (7) running, said cargo fork lift mechanism (2) and multi-axis robot (6) are mounted on the frame body (7), in the multi-axis robot (6) output terminal connected to crawl agencies (5), fork lifting mechanism (2) includes a second servo motor and the second servo motor by a first drive screw (202).

Image:

Source:
- CN103878759 A

Evaluation by Fraunhofer

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<tr>
<td>High</td>
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Selected patent documents on sensors and embedded systems
Selected patent documents on information security in industrial context
Key idea behind the patent:

- The utility model provides an industrial, automation intelligent monitoring early warning system.
- The system collects working state data of electric equipments through arrangement of the intelligent electrical parameter collector and the like, uploads the data to the monitor center industrial control computer through a GPRS wireless mode for on-line display control, and achieves on-line monitoring and early warning of industrial automation.
- Industrial electric equipment include water pump, air conditioner host, single phase motor, and/or three phase motor. Industrial meters including electrical meter, water meter, and/or gas meter. Sensors include temperature and humidity sensor, thermocouple sensor, thermo-resistance sensor, gas sensor, and/or pressure sensor. Switching equipment include high voltage circuit breaker, circuit breaker, intermediate relay, AC contactor, and/or relay.

Image:

Source:
- CN204012927 U

Legal status:
- Utility model CN, active since 20140626
CN204012927 U: Detailed image

- Industrial specialized distribution voltage transformer
- Metering configured current transformer
- Smart electric parameter collector
- GPRS wireless communication data transmitter
- Monitoring center industrial control computer transmitter
- Industrial electric equipment
- Metering configured current transformer
- Smart electric parameter collector
- 485 Bus collector
- Monitoring center industrial control computer transmitter
- Industrial meter
- Signal conditioner
- 485 Bus collector
- Monitoring center industrial control computer transmitter
- Sensor
- Signal conditioner
- 485 Bus collector
- Monitoring center industrial control computer transmitter
- Switching equipment
- Signal conditioner
- 485 Bus collector
- Monitoring center industrial control computer transmitter
Selected patent documents on smart applications of Industry 4.0
INTERNET OF THINGS BASED INDUSTRIAL EQUIPMENT MONITORING SYSTEM AND METHOD THEREOF

Key idea behind the patent:

- The invention discloses an Internet of Things based industrial equipment monitoring system and a monitoring method. The monitoring center develops implementation strategies and issues the same to the data server systems, and the data server systems analyze the implementation strategies and issue implementation strategies of which the targets point to the M2M hardware terminals to the M2M hardware terminals;

- Data server system comprises: Network communication module, which is used for internet connection management to receive and transmit data. Data resolving module, which is used to resolve downward execution strategy and upward data. Link state record module, used to record status of the connected M2M hardware terminal. Data management module, to provide real-time data and status information for application platform. The network communication module is connected with data resolving module, data management module and link state module separately, data resolving module, data management module and link state module are connected sequentially.

Image:

Monitoring center

Data server

Communication network

M2M Hardware

Industrial equipment

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Source:
- CN102692897 B

Legal status:
- Patent granted in CN, priority date 20120507

Technological level of patent applicant: Moderate
CN102692897 B: schematic block diagram of a system for implementing the present invention
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