ANALYSIS OF INDUSTRY 4.0 IN CHINA ("工业4.0")

White Paper 1: Analysis of Chinese patenting activities
A proposal to structure the theme «Industry 4.0»

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<th>Data Generation</th>
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<td>Energy &amp; resource management</td>
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<td>Smart actuators</td>
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<td>Self-adaptive process automation</td>
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## Four parts of the analysis „Industry 4.0 in China“

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Outline of part 1 „patent analysis“

- Three countries benchmark USA-CN-GER
- Fokus China: R&D topics, important players, and selected patents
- Summary and recommendations
With regard to the number of granted patents USA is No. 1 followed by China and Germany.
Publications of priority application since 2013. China has taken the leadership in terms of patent quantity.

US: 1065
DE: 441
CN: 2541
China focuses on the fields: network topology, energy-efficient network modules as well as RFID-equipments.

409 Players


346 Players


272 Players

Chinese patenting activities in Industry 4.0 are heavily accelerating*
Patent data from the last 18 months is not considered

* Number of Chinese priority applications per year
Outline of part 1 „patent analysis“

- Three countries benchmark USA-CN-GER
- **Fokus China: R&D topics, important players, and selected patents**
- Summary and recommendations
China is moving towards advanced technological fields
From central control system to intelligent, decentral and self-adaptive control

Time frame: 2005 to 2013
Analysis of 513 granted patents

Time frame: 2013 to 2015
2541 new publications
Leading Chinese companies in Industry 4.0

- Ca. 600 Chinese companies joined the CeBIT 2015 and exhibit solutions for “Big Data and Analytics, Cloud-Applications, Mobile, Social Business, IT security and Internet of Things.

- More than 300 Chinese companies and research institutes have applied patents on “Industrie 4.0”.

- Zeng Xuezhong, CEO of ZTE's terminal product department: “we will overtake Apple in the smart manufacturing of industry 4.0 in the future”.


Active patent applicants from China, → next page for more information
The most important Chinese players in Industrie 4.0 with regard to number of granted patents

However the statistics of new applications should be 300% higher.

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<tr>
<th>Applicants</th>
<th>Granted patents in CN</th>
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<tr>
<td>Univ Chongqing Posts And Telecom</td>
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<td>Univ Huazhong Science Tech</td>
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<td>Univ Southeast</td>
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<td>Huawei Tech Co Ltd</td>
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<td>Univ Shanghai Jiaotong</td>
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<td>Univ Tsinghua</td>
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<td>Univ Shanghai</td>
<td>6</td>
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<td>Zte Corp</td>
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<td>Harbin Inst Of Technology</td>
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<td>Univ Zhejiang</td>
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<tr>
<td>Univ Dalian Tech</td>
<td>4</td>
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</table>

*Selection criteria: At least 4 granted patents in China since 2005
Selected high-impact Chinese inventions on Industry 4.0 (1/10)

**Source:** CN101951640A

**Title:** INDUSTRIAL WIRELESS NETWORK MEDIA ACCESS CONTROL METHOD

**Abstract:** The invention relates to an industrial wireless network media access control method. In the control method, four types of frames, namely a beacon frame, a data frame, a response frame and a command frame are specified; meanwhile, in the operating process of the method, a protocol session mechanism, an access mechanism, an interframe forced waiting mechanism, a withdrawing mechanism after a busy channel is detected, a data retransmission mechanism and a packet receiving repeated monitoring mechanism are integrated into a system through a state machine. In the method, a superframe mechanism is adopted and a competition period and a non-competition period in each superframe are allocated according to a periodic communication task and an aperiodic communication task in the industrial Internetof things, so that real-time scheduling of the periodic communication task and the aperiodic communication task which are transmitted by an upper layer in a data link layer is considered, and negative effects of severe reduction in the communication quality of wireless technology in an industrial environment on industrial network application can be effectively relieved.
Selected high-impact Chinese inventions on Industry 4.0 (2/10)

Source: CN102411699A

Title: ADAPTIVE FREQUENCY TRACKING SYSTEM USED IN PASSIVE SENSING ELECTRONIC TAG READER

Abstract: The invention belongs to the Internet of things perception layer technology field and discloses an adaptive frequency tracking system used in a passive sensing electronic tag reader. The system comprises: a PLL circuit, a driver circuit, a power amplifier circuit, a series resonance loop formed by an antenna coil and a resonant capacitor, a voltage dropping resistor, a sine wave square wave conversion circuit and a delay circuit. The PLL circuit comprises: a PFD, a charge pump, a loop filter, a voltage current converter and a flow control oscillator. The flow control oscillator has two way quadrature output of I and Q. An I way voltage signal is output to an antenna through the driver circuit and the power amplifier circuit. After passing through the delay circuit, a Q way output voltage signal CLKQ is connected with a Data input terminal of the PFD. By using the system, the carrier wave frequency of the passive electronic tag reader can automatically track the series resonance frequency of the antenna. An emission power of the reader can reduce because the antenna resonant frequency changes caused by an environment factor, a manufacturing process factor, a working mode and the like. By using the system of the invention, the above problem can be solved and a system working distance can not be reduced. And many other problems can be solved too.
Selected high-impact Chinese inventions on Industry 4.0 (3/10)

**Source:** CN102692897A

**Title:** INTERNET OF THINGS BASED INDUSTRIAL EQUIPMENT MONITORING SYSTEM AND METHOD THEREOF

**Abstract:** The invention discloses an Internet of Things based industrial equipment monitoring system and a monitoring method thereof, wherein the system comprises: sequentially connected components of a monitoring center, data server systems, a communication network, M2M hardware terminals and industrial equipment. The method includes that: 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; the M2M hardware terminals connected with the industrial equipment specifically execute the implementation strategies. The system and the method in the invention solve the problems of low informatization level, decentralized management, resource waste, low efficiency and the like in monitoring technologies of the existing industrial equipment. Real-time acquisition of the industrial equipment operation data can be realized through the M2M hardware terminals, and the obtained data is provided to the monitoring center through the data server systems; further, the monitoring center on the Internet can timely and accurately obtain the equipment data through the issue of the implementation strategies, thereby improving resource utilization rate and efficiency
Selected high-impact Chinese inventions on Industry 4.0 (4/10)

Source: CN102594705A

Title: Non-IP (Internet Protocol) data transmission method suitable for wide-area internet of things

Abstract: The invention discloses a non-IP (Internet Protocol) data transmission method suitable for a wide-area internet of things. The non-IP data transmission method is characterized in that the method transmits data through the following steps that: the data assembles a data identification on a data manufacturing node, and the data identification is released to a network; the data uses the node to publish a data declaration to the network, and a routing node modifies a network connecting relation table and a routing table according to the received data declaration; the routing node transmits the data to different directions according to the data identification carried by the data and the routing table until the data reaches a data using node; and when the data using node does not need the kind of data, the data using node sends the data declaration and notifies the network that the data using node is not the destination of the kind of data. According to the method, a many-to-many (m:n) transmission mode of the data network is realized, i.e., the data with m data sources is transmitted to n data receiving nodes through the network (m is larger than n). The method is applied, so that the data transmission of an IP address according to the data identification not a destination node can be realized. The method is suitable for the data transmission of the wide-area internet of things.
Selected high-impact Chinese inventions on Industry 4.0 (5/10)

Source: CN101996478A

Title: WIRELESS NETWORK BASED ENERGY CONSUMPTION DATA ACQUISITION SYSTEM

Abstract: The invention relates to a wireless network based energy consumption and/or industrial energy consumption data acquisition system. The system adopts at least one data acquisition device which is used for acquiring building and/or industrial energy consumption parameter and transmitting the acquired energy consumption parameter to the external device, the system is connected with the data acquisition device by virtue of a wireless network, and a data receiving device receives energy consumption parameter transmitted by the data acquisition device by virtue of the wireless network, thus realizing a wireless network building and/or industrial energy consumption data acquisition system with good expansibility, flexible mounting and maintenance convenience.
Selected high-impact Chinese inventions on Industry 4.0 (6/10)

Source: CN102176155A
Title: PROGRAMMABLE SYSTEM AS WELL AS DEPLOYMENT AND CONTROL METHODS BASED ON INDUSTRIAL WIRELESS FREQUENCY-HOPPING SPECTRUM-SPREAD

Abstract: The invention discloses a programmable system as well as deployment and control methods based on industrial wireless frequency-hopping spectrum-spread; the system comprises a gate sub-system and N field wireless access devices, wherein the gate sub-system is composed of N wireless access points (APs) and an industrial integrated monitoring host, each field wireless access device comprises a wireless client module ST, a communication processor module and a local control unit (LCU). The deployment method comprises deploying a gate monitoring sub-system in a gate integrated monitoring centre; deploying N field wireless access devices; and deploying the LCU and an execution element thereof. The control method comprises a remote wireless control method, a local PLC (programmable logical controller) automatic control method and a general relay manual control method, wherein the remote wireless control method comprises a remote automatic control method and a distance automatic control method which is forcibly executed by an upper computer. The programmable system and the deployment and control methods based on industrial wireless frequency-hopping spectrum-spread are easy for wiring, low in cost, simple for maintenance and high in reliability.
Selected high-impact Chinese inventions on Industry 4.0 (7/10)

**Source:** CN101854762 A  
**Title:** WIRELESS NETWORK BASED PLANT TISSUE CULTURE LED LIGHT SOURCE CONTROL SYSTEM

**Abstract:** The invention discloses a ZIGBEE wireless network based plant tissue culture LED (light-emitting diode) light source control system, aiming to solve the problem that a plant tissue culture light source system cannot be monitored and treated with full time sections at present. The invention adopts the technical scheme that the wireless network based plant tissue culture LED light source control system comprises a master control end and a plurality of slave control ends. The system is characterized in that the master control end comprises a first microprocessor, a second microprocessor, a memory, a real-time clock, a display device, a temperature sensor, a humidity sensor, a serial communication interface (SCI), a USB (Universal Serial Bus) communication interface, operation keys and control software embedded in the two microprocessors; and each slave control, end comprises a third microprocessor, an extended memory, a real-time clock, an SCI, a temperature sensor, a humidity sensor, an I/O (input/output) extended interface and control software embedded in the third microprocessor. The invention can be used for carrying out centralized control on LED light, sources in a large-scale field.
Selected high-impact Chinese inventions on Industry 4.0 (8/10)

Source: CN101835234A
Title: INDUSTRIAL WIRELESS SENSOR NETWORK COMMUNICATION METHOD BASED ON RELAY NODES

Abstract: The invention relates to an industrial wireless sensor network communication method based on relay nodes, belonging to the field of sensor network communication. A network management center distributes a preferred communication path resource according to the request of a source node and current network state information, selects a relay node and a relay path according to constraint conditions, and distributes the communication resources of the relay path. In the communication process, when the relay node receives the negative response from the node of the last hop, the probability that the transmission delay exceeds a threshold is reduced, the frequency of retransmission initiated by the source node is reduced, and the energy consumption for retransmitting data is reduced. Meanwhile, the relay node also dynamically changes the priority of data packets, avoids delaying transmission of the data packets again, and ensures that the data packets reach a destination node in delay requirements. By adopting collaboration among the relay node, the destination node and the network management center, the packet loss rate is reduced, the frequency of retransmission initiated by the source node is reduced, and the energy consumption for retransmitting data is reduced.
Selected high-impact Chinese inventions on Industry 4.0 (9/10)

Source: CN101754423 A
Title: COMMUNICATION METHOD FOR MESH AND STAR TOPOLOGY STRUCTURE WIRELESS SENSOR NETWORK

Abstract: A method of achieving wireless sensor network (WSN) communication in a mesh and star topology network (MSTN), including: a) connecting a plurality of nodes in a WSN to form a mesh and star hybrid topology structure; b) based on the topology structure, defining a superframe structure based on IEEE 802.15.4-2006; c) based on the topology structure and superframe structure, defining methods for long period data processing, connectivity assessment, medium access control, channel measurement, frequency hopping, beacon frame formation, and two-stage resource allocation; d) based on the topology structure, superframe structure, and methods, defining a method for network establishment; and e) based on the network establishment method, defining a method for MSTN communications. The method features real-time communication, high reliability, and low energy consumption.
Selected high-impact Chinese inventions on Industry 4.0 (10/10)

Source: CN101917752A
Title: CONVERGENT ROUTING METHOD OF WIRELESS SENSOR NETWORK BASED ON PARETO OPTIMUM PATHS

Abstract: The invention relates to a convergent routing method of a wireless sensor network based on Pareto optimum paths, wherein the sensor network comprises a plurality of sensor nodes arranged in a monitoring area and a convergent node and adopts a collecting tree routing method based on a Pareto multi-target optimization strategy. The convergent routing method meets the requirements of the fields of industrial monitoring and the like for real-time and reliable multi-target transmission performance by establishing a Pareto optimum multi-path route, has the advantages of simple algorithm structure, easy realization and less resource occupation; and besides, the method has stronger applicability and flexibility on the selection of transmission paths and provides an effective solution for the wider application of sensing networks.
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.

Image:

Source:
- CN201099964Y (CN2010)

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

The study will contain translations, manual summarization and evaluation from experts.

### Evaluation by Fraunhofer

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Outline of part 1 „patent analysis“

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Summary and recommendations

- China is an attractive market for solution providers of industry 4.0. China will carry out pilot projects with international experts.
- Unlike in the past, Chinese industry and research institutions make use of IPR in order to protect their ideas prior to external cooperation.
- China will make use of its huge IPR portfolio to define national and international standards. External solution providers will have to accept Chinese standards and regulations.

Therefore we recommend the solution providers of industry 4.0:

- to structure the theme »industry 4.0« according the strategic orientation of each company
- to monitor Chinese activities cost-efficiently by ordering the semi-annual report »Chinese Industry 4.0 Patents«
- to delete invalid Chinese patents and to invent around key inventions
- to participate at the research project „China TechWatch“ in order to have access to up-to-date analysis methods.
A cost-efficient way to monitor Chinese patenting activities in Industry 4.0.

- Semi-annual publication
- Language: English
- Overview of about 1000 newest Chinese patent and utility model publications in Industry 4.0
- Keywords: Smart sensors, smart actuators, identification technologies, wireless sensor networks, bus topologies, embedded systems, artificial intelligence, advanced automation, robotics, smart services
- Detailed analysis and evaluation of 50 most important publications
- Price: 2000 Euro/Volume
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