The Internet of Things (IoT) provides big opportunities for technologies. The device business will reach $45B in 2024, contributing to a total IoT market of $400B.
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Companies Listed in this Report

Key Features

The objectives of this report is to provide:

- Understanding of IoT value chain structure (device, data cloud), application areas and technologies involved

- Technology trends and evolution of IoT device in the coming years

- Market forecast for IoT devices in Munits and $M for 2014 – 2024, with a focus on sensors

- IoT applications and examples overview (building automation, transportation, healthcare, industry, etc.) with a focus on wearable electronics

- The technological challenges faced by IoT devices, with a focus on wireless, energy, power, RF and sensing modules
Who Should Be Interested in this Report?

- **R&D, Components Manufacturers Companies**
  - Evaluate market potential of future IoT technologies and products for new applicative markets
  - Spot new opportunities and define diversification strategies
  - Position your company in the ever changing IoT market structure

- **OEMs & Integrator Companies**
  - To evaluate benefits of integrating sensors in IoT devices
  - Get the list of key players and emerging start-ups in this industry

- **Cloud & Telecommunications Companies**
  - Understand the evolution of IoT devices and the market structure
  - Understand the differentiated value of products and services in this market
  - Identify new business opportunities and prospects

- **Financial & Strategic Investors**
  - Understand the potential of incoming Internet of Things revolution
  - Get the list of key players and emerging start-ups in this industry
Report Scope

• Yole’s definition of the Internet of Things is as follows:
  – Internet of Things devices is the aggregation of all the sensing modules that are linked
to the Cloud – either directly or through a gateway – and which data is processed and
valorized in any manner (through selling to a third party, through monitoring of a piece
of equipment, etc.).

• This report looks at the Internet of Things market in general, but with a strong
focus on sensing modules. We do not detail the cloud computing industry nor
the data processing services.

• We do not include in our valorizations the benefit brought by IoT solutions
through productivity gains. The values estimated are from hardware, cloud
computing processing services and data processing services charging.
IoT Global Market Structure (1/3)

- Information Flux
- Statistics
- Targeted Ads
- Service Companies
- Third Party

Data

Hardware

Cloud

Connected Devices

- Wireless Sensor Module

- HUB / Gateway

- Cloud Companies

- Information Flux
Area Of Application

- Building Automation
- Retail & Logistics
- Consumer & Home automation
- Healthcare & Life Science
- Industrial
- Transportation
- Security & Public Safety
- Environment
Summary of Technologies of IoT
Markets and Sensors

- Here are the main applications of IoT devices and sensors associated with.

Legend:
- Sensor
- Level of demand

THE INTERNET OF THINGS

Building Automation
- Light (IR, visible)
- Temperature
- Chemical (CO2)
- Accelero

Healthcare & Life science
- Pressure
- Temperature
- Chemical
- Light (IR, X-Ray)
- Bio Sensors
- Inertial

Consumer & Home automation
- Gyroscope
- Accelero
- Magneto
- Pressure
- Temperature
- Chemical

Transportation
- Gyroscope
- Accelero
- Magneto
- Chemical
- Pressure
- Temperature

Industrial
- Pressure
- Hall Effect
- Chemical
- Accelero
- Temperature
- Light (IR, visible)
- Pressure

Environment
- Chemical
- Humidity
- Light (IR, Optical)
- Accelero
- Temperature
- Light (IR, visible)

Security & Public Safety
- Gyro
- Accelero
- Magneto
- Chemical
- Light (IR, X-Ray, THz)

Retail & Logistics
- Light (IR/Optical)
- Magneto
- Pressure
- Temperature
- Chemical
IoT Wireless Sensors Map

**SENSING MODULE**
- Accelerometers
- Magnetometers
- Gyroscopes
- Acoustic Sensors
- Pressure Sensors
- Humidity Sensors
- Temperature Sensors
- Proximity Sensors
- Image Sensors
- Light Sensors
- Gas RFID Sensors
- Micro Flow Sensors

**RF MODULE**
- Signal Processing Unit
- Radio Transceiver
- Duplexer
- BAW
- Wifi
- ZigBee
- Bluetooth LE

**ENERGY STORAGE MODULE**
- Li-Ion battery
- AAA/AA Batteries
- Energy Harvesting

**POWER MANAGEMENT MODULE**
- Ultra-capacitors
- Microbatteries
- PMU

**ENVIRONMENTAL MODULE**
- Ultra-capacitors
- Microbatteries

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Solution Price IoT Roadmap

Solution Price per sensor module

- **Rosemount 3051C Smart Pressure Transmitter**
  Source: Rosemount

- **NEST Smart Thermostat**
  (current price: $250)
  Source: NEST

- **Fitness Activity Tracker**
  (current price: $130)
  Source: Jawbone

- **Multiple temperature sensors for home automation**
  (current price: $75)
  Source: EnOcean

- **MEMS-based chemical sensing**
  Source: Optoi Microelectronics

- **Sensors’ swarm - Michigan Micro-Mote**
  Source: University of Michigan

- **Batch-level RFID Temperature Sensor Tags**
  (current price: $ range)
  Source: ThinFilm Electronics

- **Item-level RFID sensor tags**
Summary of Technologies of IoT
Forecast: Hardware Market Value by Application Domain

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Value Market ($M)</th>
<th>Environment</th>
<th>Security &amp; Public Safety</th>
<th>Retail &amp; Logistics</th>
<th>Industrial</th>
<th>Healthcare &amp; Life Science</th>
<th>Consumer &amp; Home Automation</th>
<th>Building Automation</th>
<th>Automotive</th>
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<td>2014</td>
<td>9,458</td>
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<td>13,125</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>27,575</td>
<td>1,200</td>
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<td></td>
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<td>48,075</td>
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<td>2018</td>
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<td></td>
<td>52,975</td>
<td>4,940</td>
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<td></td>
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<td>45,045</td>
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<td>54,555</td>
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<td>31,390</td>
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<td>26,870</td>
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<td>47,005</td>
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<td>2023</td>
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<td>13,920</td>
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<td>2024</td>
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<td>12,560</td>
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</table>

Market Value by Domains of Applications ($M)

- Total Value Market
- Environment
- Security & Public Safety
- Retail & Logistics
- Industrial
- Healthcare & Life Science
- Consumer & Home Automation
- Building Automation
- Automotive

CAGR: 42%, 124%, 113%, 139%, 32%, 165%, 29%, 80%, 140%
The global wearable electronics market can be segmented in 5 categories. Head-Wear category includes helmet product and vision aid. There’s also a category of products for neck-wear, with collars and necklace products that cover up electronics with jewels. Arm-Wear category is the most burgeoning category with multiples devices expected wristband, smart watches, ring, armband, etc. Body-Wear products include smart clothing, and devices monitoring back/spine position. And the last category concerns foot-wear.

Arm-Wear market is one of the most promising market and many actors are targeting it.
Wearable electronics is a new big opportunity for sensors

- Fitness / activity monitoring, healthcare, sports applications
- In many cases the sensor acts as a hub
  - Basic calculations can be done at the device level
  - After transmission (enabled by low energy Bluetooth): advanced software / fusion can be done by the smartphone
- Below are many examples of such developments:

- I’m watch (2012)
  - Integrates accelerometer + magnetometer

- Moto 360 by Motorola (End 2014)
  - Other connected watches are currently in development by major OEMs
    (LG G Watch, rumors about Apple iWatch…)

- Pebble Watch (0.4 MUnits sold in 2013)
  - Features STMicroelectronics accelerometer
Wearable Electronic / Connected Devices
Examples of new devices (2/4)

BodyMedia (Acquired by Jawbone in 2013)
- Integrates MEMS accelerometer (from Kionix and STMicroelectronics) in its systems for fitness application
- We note that no gyroscopes are used presently. This would enable more precise monitoring and new sport applications, however power consumption would be too high. It could be part of larger systems in the future.

Cell Phone as a Hub

Jawbone Up24

NodeKore from Variable Technologies

MYO by ThalmicLabs
- Proprietary EMG muscle activity sensors
- Nine-axis IMU containing:
  - three-axis gyroscope
  - three-axis accelerometer
  - three-axis magnetometer

BodyMedia

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- Thin Wafer Handling
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The Internet of Things (IoT) provides big opportunities for technologies. The device business will reach $46B in 2024, contributing to a total IoT market of $400B.

The ratio between electronic components and data processing can reach 1:50 in certain long-term cases! This is easily understandable, since the main purpose of the IoT is to make sensing ubiquitous at a very low cost, resulting in extremely strong price pressure on electronic component manufacturers. Nevertheless, the next five years will be extremely fruitful for device makers; the market should reach $70B by 2018, before decreasing. This period represents a key window in which manufacturers must seize the opportunity to grab a piece of the IoT business pie.

The IoT is a multi-billion dollar market emerging from several different markets (i.e. industrial sensors, wearable electronics and home automation) which will see strong convergence in the next five years. Three industrial and service sectors will be integral to the valorization of this new market:

- The electronics industry, which will manufacture the sensing devices
- The communication and cloud data storage industry, which will handle data transmission, storage and processing
- Service companies, which will valorize the data either through processing or by selling to a third party

Some companies have already started positioning themselves in these fields: for example, Oracle and Amazon are developing their cloud computing capabilities; Bosch Connected Devices and Solutions GmbH and STMicroelectronics have teams dedicated to the IoT; and Google and Facebook are continuously developing their data processing models while looking to acquire companies linked to data gathering. Of course, not all of them will be winners.

The short-term opportunity lies in the electronics industry. Indeed, very strong price pressure is expected for IoT devices, and strong volumes are expected but at very low cost. Even though the general electronics market will experience strong growth, it will be through decreased costs, increased manufacturing capabilities and reduced margins. This trend has already been seen in the MEMS field over the past few years, and will repeat itself in the future.

The same is to be expected for the cloud computing industry. Large investments in terms of data storage will be needed, but strong price pressure is expected, and an overall low value will be attributed to the physical data. Actually, the war on price has already begun between the major cloud computing companies, which are cutting data storage prices while growing their capabilities.

Meanwhile, on the data processing side, more and more information will be available, and at low cost. The more data, the higher the value, and all of this with low overall infrastructural investment. Service companies will be the big winners in this field. In
The Internet of Things roadmap

The array of technologies available – and soon to be available – is immense. Nevertheless, the evolution of sensing modules for the IoT will follow a predefined trend that can be summarized in a series of seven product generations, including large industrial smart sensors, an advanced generation of sensors, and polytronics. These generations are detailed in Yole Développement’s report, but a few examples are described below:

- One of these generations, already being seen today, is actually the first generation of sensing modules dedicated to IoT application. These devices represent the integration of off-the-shelf electronic components in a single package in order to offer new functionality. Not much effort has yet been given to integration, as the main focus has been on bringing a new function to market. Today, examples of such devices are numerous; some, such as the Nest (now Google) smart thermostat, find market interest and success - while others, i.e. "smart forks", "smart sprinklers" and other "smart" devices, don’t. Other devices are addressing domains such as wearable electronics and home & building automation. For these devices, we expect a market volume of 200M units by 2017, representing a market potential of $83B.

- One example of a future sensing generation is integrated sensors, which are expected for 2020 and which will be the one to democratize IoT. Its general description is “the integration of IoT-dedicated electronic components” – meaning very small, very low-cost, very low-power consumption components like MEMS-based sensors. The essence of such devices is to be low cost and thus ideal for high-volume applications, with low-power wireless protocols, ultra-low power electronics. One example of such a device is the integration of a hazardous chemicals sensor in an industrial worker’s gear. Another example is the integration of connected condition-monitoring sensors in a car engine. We expect a market volume of 2B units for these devices by 2021, representing a market potential of $107B.

This report provides a detailed analysis of these generations and the technical and market challenges they must overcome before reaching the market. Yole Développement’s analysis shows how these challenges can be defeated in order to strengthen market growth.

FROM HARDWARE TO CLOUD TO DATA PROCESSING: WHERE WILL THE IOT’S VALUE FLOW?

The Internet of Things is a mix of hardware, cloud and data processing; a generic concept encompassing a wide variety of applications that belong to numerous domains.

For Yole Développement, the IoT is defined as the aggregation of all the sensing modules which are linked to the Cloud – either directly or through a gateway – and with which data is processed and valorized in any manner (selling to a third party, monitoring a piece of equipment, etc.).

We focused on the analysis of technical characteristics of IoT devices such as the nature of the electronic components to use, the corresponding RF protocols, device power consumption, etc.; as well as economic characteristics, especially regarding the IoT’s value, and where market potential lies.
Our roadmap is based on analysis of:

- Current state-of-the-art electronics, and the large number of technologies in development.
- The current technological evolution of wireless transmission regarding protocols & standards.
- The recent discussions and actions pertaining to consumer privacy and data security.
- Sensor multiplicity and integrated sensor developments.
- Additional topics such as solutions costs, and where market traction comes from.

Also, it's still unclear which technological platform will be used, which data transmission protocols will be chosen, and which business model will be proven. Many applications are striving for the blue ribbon, but only the proven ones will drive volume.

This report analyzes the strong challenges awaited regarding the identification of those applications which are expected to provide market volume, and those which are bound to fail.

OBJECTIVES OF THE REPORT

This report aims to provide:

- An understanding of the IoT value chain structure (device, cloud, data), application areas and technologies involved
- The future evolutionary trend of IoT device technology
- A market forecast for IoT devices in Munits and $M for 2014-2024
- IoT applications & examples overview (building automation, transportation, healthcare, industrial...)
- The technological challenges facing IoT devices

COMPANIES CITED IN THE REPORT (non-exhaustive list)


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Licenses: The product reports and databases, 3 different licenses are proposed. The buyer has to choose one license:

• One user license: one person at the company can use the report.
• Multi-user license: the report can be used by unlimited users within the company. Subsidiaries and Joint-Ventures are not included.
• Corporate license: purchased under “Annual Subscription” program, the report can be used by unlimited users within the company. Joint-Ventures are not included.

“Products”: Depending on the purchase order, reports or databases on MEMS, CSC, Optics/MOEMS, Nano, Bio... to be bought either under a single purchase order or a multi-purchase order subscription, (i.e. subscription for a period of 12 calendar months). The annual subscription to a package (i.e. a global discount based on the number of reports the Buyer wishes to purchase, and the software and IT service, if any, on line on 1-micronews and a consulting approach), is defined in the order. Reports are established in PowerPoint and delivered on a PDF format and the database may include Excel files.

“Seller”: Based in Lyon (France headquarters), Yole Développement is a market development and research company. It develops an access for advanced technology industrial projects. With more than 20 market analysts, Yole works worldwide with the key industrial companies, R&D managers and investors to help them understand the markets and technology trends.

1. SCOPE

1.1 The Contracting Parties undertake to observe the following general conditions when agreed by the Buyer and the Seller. Any ADDITIONAL, DIFFERENT, OR CONFLICTING TERMS AND CONDITIONS IN ANY OTHER DOCUMENTS ISSUED BY THE BUYER AT ANY TIME ARE HEREBY OBJECTED TO BY THE SELLER, SHALL BE WHOLLY INAPPLICABLE TO ANY SALE MADE HEREUNDER AND SHALL NOT BE BINDING IN ANY WAY ON THE SELLER.

1.2 This agreement becomes valid and enforceable between the Contracting Parties upon execution of this order. The order is irrevocable and is effective release. In this case, the Seller shall use its best efforts to inform the Buyer of an indicative release date. If the Seller fails to provide this order before 8 days of receipt of the Products. for this purpose, the Buyer agrees to produce sufficient evidence of such defects.

2. MAILING OF THE PRODUCTS

2.1 Product delivery shall be paid by the Buyer:
• within (1) month from the order for Products already released;
• or
• within a reasonable time for Products ordered prior to their effective release. In this case, the Seller shall use its best endeavours to inform the Buyer of an indicative release date and provide the Buyer with an estimated delivery date.

2.2 Some weeks prior to the release date the Seller can propose a pre-release discount to the Buyer.

The Seller shall by no means be responsible for any delay in respect of its order, whether caused by the circonstances where a new event or access to new contradictory information would require for the analyst extra time to compute or compare that the Vendor in order to enable the Seller to deliver a high quality Product.

2.3 The mailing of the Product will occur only upon payment of the Product under article 3.

2.4 The mailing is operated through electronic means either by email or by mail. Certain Product, however, cannot be transmitted to mailboxes due to its confidential nature. The electronic delivery format is defective, the Seller undertakes to replace it no charge to the Buyer provided that it is informed of the defective format within 90 days from the date of the original download or receipt of the Product.

2.5 The person receiving the Products on behalf of the Buyer shall immediately verify the quality of the Products and their conformity to the order. Any claim for apparent defects or for non-conformity shall be sent to the Buyer within 8 days of receipt of the Products. For this purpose, the Buyer agrees to produce sufficient evidence of such defects.

2.6 No returns or exchanges of Products or any Product that require prior information to the Seller, even in case of delayed delivery. Any Product returned to the Seller without providing prior information shall be rejected. In case no return needs to be required under article 2.5 shall remain at the Buyer’s risk.

3. PRICE, INVOICING AND PAYMENT

3.1 Prices are given in the orders corresponding to each Product sold on a unit basis or corresponding to annual subscriptions.

The price of this invoice shall be subject to change and the price of the report can be reevaluated from time to time. The effective price is deemed to be the one applicable at the time of the order.

Yole may offer a pre release discount for the companies willing to acquire in the future the specific report and agreeing on the following general conditions:

3.2 Payments due by the Buyer shall be sent by cheque payable to Yole Développement, credit card or by electronic transfer to the following account:

HSBC, 1 place de la Bourse 69002 Lyon France
Bank code: 30056
Branch code: 001
Account n°: 0170 200 1565 87
BIC or SWIFT code: CCFRFRPP
IBAN: FR73 30056 0170 200 1565 87

To ensure the payments, the Seller reserves the right to request down payments from the Buyer. In this case, the need of down payments will be mentioned on the order.

3.4 Payment due by the Buyer shall be paid within 30 days from invoice date, except in the case of a particular written agreement. If the Buyer fails to pay within this time and fails to contact the Seller, the latter shall be entitled to invoice interest in arrears based on the annual rate Ref of the «EC+» 7 points, in accordance with Article L. 441-6 of the French Commercial Code. Our publications (report, database, tool...) Depending on the purchase order, reports or programs or information) arising out of the use of or inability to use the products, (including any damages of any kind, including without limitation, incidental or consequential damages (including, but not limited to, damages for loss of sales, business interruption and loss of programs) information or data) for any reason, the buyer agrees to respect of the copyrights and will guaranty that the Products are not disseminated out of the company.

3.5 In the context of annual subscriptions, the person of contact shall deliver to the other, only the employee of the Buyer can access the report or the employee of the companies in which the Buyer have 100% shares. As a matter of law, the Informer of a company, the joint venture done with a third party etc...cannot access the report and should pay a full license price.

7. TERMINATION

7.1 If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the direct or indirect costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential consequences to their entirety.

7.2 In the event of breach by one Party under these conditions or the order, the non-breaching Party may send a notification to the other by recorded delivery letter upon which, after a period of 30 days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

8. MISCELLANEOUS

All of these terms and Conditions are for the benefit of the Seller itself, but also for its licensors, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer. Any dispute arising out or linked to these Terms and Conditions shall be settled by the French Commercial Courts of Lyon, which shall have exclusive jurisdiction upon such issues.

9. Governing Law and Jurisdiction

Any dispute arising out or linked to these Terms and Conditions or the order, or any contract arising out of the use of the Products or the information provided, or any other document or activity related herein, shall be settled by the French Commercial Courts of Lyon, which shall have exclusive jurisdiction upon such issues.

5. FORCE MAJEURE

The Seller shall not be liable for any delay in performance directly or indirectly caused by or resulting from acts of nature, fire, flood, accident, riot, war, government intervention, embargoes, strikes, labor difficulties, equipment failure, late deliveries by suppliers or other accidents which are beyond the control, and not the fault of the Seller.

6. Protection of the Seller’s IPR

6.1 All the IPR attached to the Products are and remain the property of the Seller and are protected under French and international copyright law and conventions.

6.2 The Buyer agreed not to disclose, copy, reproduce, redistribute, resell or publish the Product, or any part of it to any third party other than employees of its company. The Buyer shall have the right to use the Products solely for its internal information purposes. In particular, the Buyer shall therefore not use the Product for purposes such as:

- Information storage and retrieval systems;
- Recordings and re-transmissions over any network (including any local area network);
- Use in any timesharing, service bureau, bulletin board or similar arrangement or public display;
- Publishing Product to an on-line service (including bulletin boards or the Internet); Licensing, leasing, selling, offering for sale or assigning the Product.

6.3 The Buyer shall be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees, agents or from third parties, the use of the Products and shall personally take care of any related proceedings, and the Buyer shall bear related financial consequences to their entirety.

6.4 The Buyer shall define its company point of contact for the needs of the contract. This person will be the recipient of any report or information. This person is responsible for respect of the copyrights and will guaranty that the Products are not disseminated out of the company.

9. GOVERNING LAW AND JURISDICTION

9.1 Any dispute arising out or linked to these Terms and Conditions or the order, or any contract arising out of the use of the Products or the information provided, or any other document or activity related herein, shall be settled by the French Commercial Courts of Lyon, which shall have exclusive jurisdiction upon such issues.