

INTERNET OF THINGS

Researches and Practices

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Which 2-word term can best characterize the silent movie?

Industrial Revolution

Industrial Revolution I

When? About 200 years ago

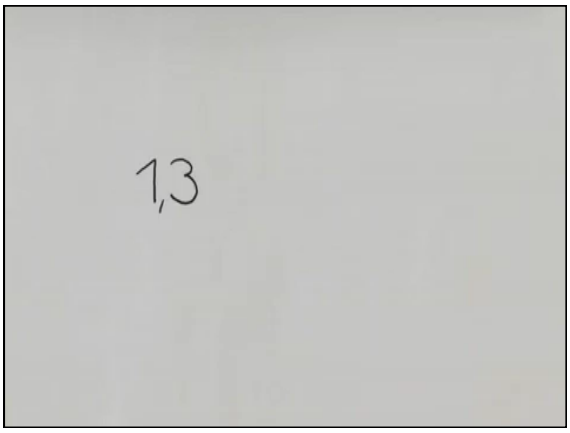
Feature? Muscle power from humans and animals was replaced by mechanical power

Result? Sharp productivity and economic growth

Industrial Revolution I

Human income per capita had taken 800 years to double by the early 1800's.

It rose 13-fold in the following 150 years.



Industrial Revolution II

Internet Revolution

Internet Revolution

When? About 60 years ago

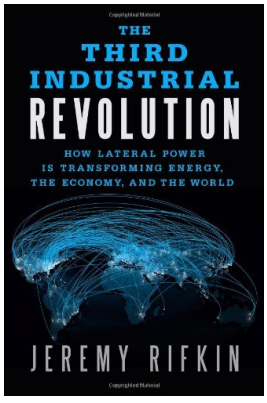
Feature? Computing, communication, networking and information storage

Result? Sharper productivity and economic growth

What is the next Industrial Revolution?

The 1st answer

People producing their own green energy in their homes, offices, and factories, and sharing it with each other in an "energy internet"



The 2nd answer is from General Electric:
Peter C. Evans and **Marco Annunziata**

Industrial Revolution III

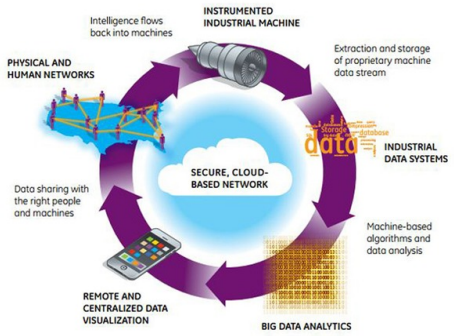
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Industrial Internet

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Intelligent Devices + Intelligent Systems + Intelligent Decisioning

GE: "**Industrial Internet**"

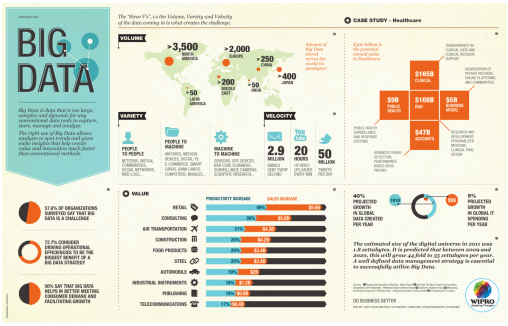


Industrial Internet

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INTERNET OF THINGS (IoT)

Other possible answer:



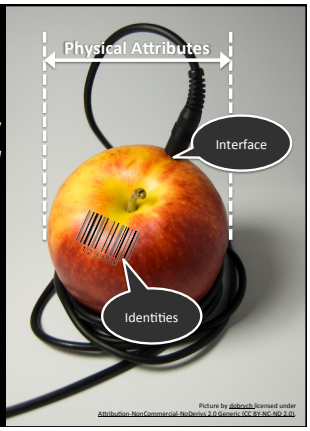
Other possible answer:

3D Printing

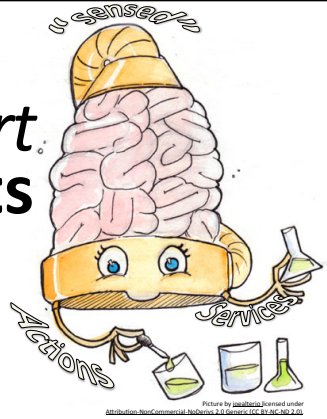


Seamlessly Integrated

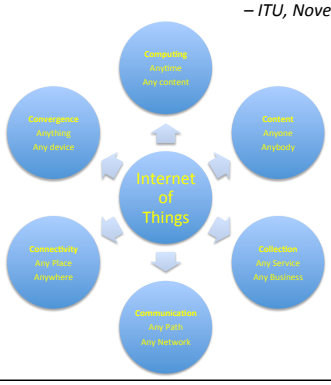
Object



Smart Objects



Internet of Things : **Any**time, **any**where, by **any**one and **any**thing
– ITU, November 2005

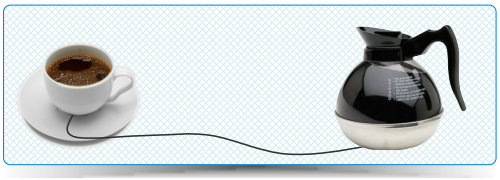


WHAT are the *proper* ARCHITECTURES for such IoT



ARCHITECTURE

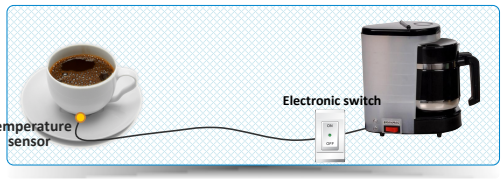
Does it make sense to network physical objects?



Direct connection of physical objects makes little sense!

ARCHITECTURE

It does make sense to connect relevant information of physical objects

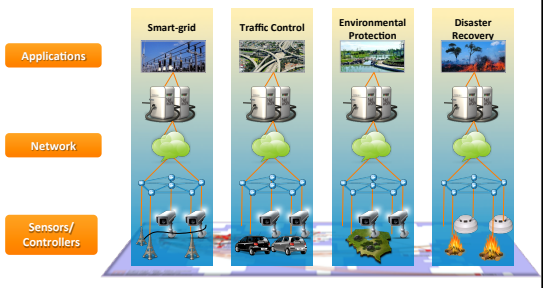


Relevant information of physical objects = status + control information

IoT = integration of sensing, computation, and control

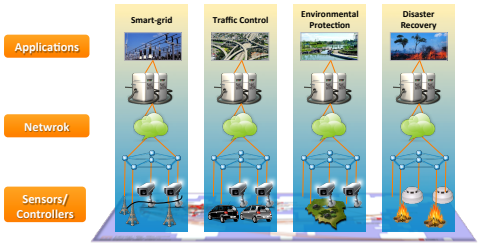
INTRANET of Things or "Net of Things"

specific *protocols* and *vertically* integrated



WHAT'S THE PROBLEM?

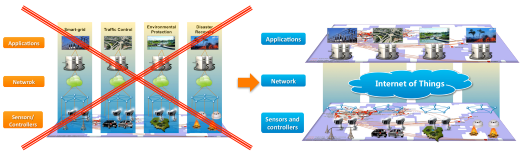
- Tightly coupled
- Repeated implementation of common functions
- High cost and less sharing (of resources)



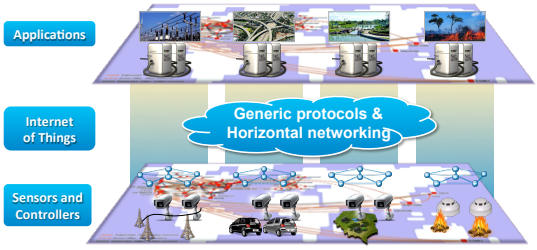
INTERNET OF THINGS

Abandon *specific* protocols and *vertical* integration

Apply *generic* protocols and *horizontal* networking



ARCHITECTURE OF IoT



HOW can one IMPLEMENT *them*



Proposal 1: Direct Use of Internet



Evaluation of Proposal 1

IoT Requirements	Proposal 1
1. Real-time	
2. Privacy	
3. Embedded computing	
4. Scalable	
5. Low cost, quick start	
6. Marketing and profitable	

Evaluation of Proposal 1

IoT Requirements	Proposal 1
1. Real-time	Not good
2. Privacy	Not good
3. Embedded computing	Impossible
4. Scalable	Good
5. Low cost, quick start	Good
6. Marketing and profitable	Not good

INFEASIBLE

Proposal 2:
Construction of a New Network



Evaluation of Proposal 2

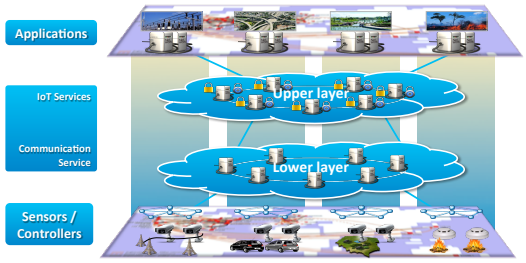
IoT Requirements	Proposal 1	Proposal 2
1. Real-time	Not good	
2. Privacy	Not good	
3. Embedded computing	Impossible	
4. Scalable	Good	
5. Low cost, quick start	Good	
6. Marketing and profitable	Not good	
OVERALL EVALUATION	Infeasible	

Evaluation of Proposal 2

IoT Requirements	Proposal 1	Proposal 2
1. Real-time	Not good	Possible
2. Privacy	Not good	Possible
3. Embedded computing	Impossible	Possible
4. Scalable	Good	Possible
5. Low cost, quick start	Good	Difficult
6. Marketing and profitable	Not good	Possible
OVERALL EVALUATION	Infeasible	High risk!

Proposal 3: A Two-Layer System

Lower layer: Use of internet as a communication carrier
Upper layer: IOT services



Evaluation of Proposal 3

IoT Requirements	Proposal 1	Proposal 2	Proposal 3
1. Real-time	Not good	Possible	
2. Privacy	Not good	Possible	
3. Embedded computing	Impossible	Possible	
4. Scalable	Good	Possible	
5. Low cost, quick start	Good	Difficult	
6. Marketing and profitable	Not good	Possible	
OVERALL EVALUATION	Infeasible	High risk!	

Evaluation of Proposal 3

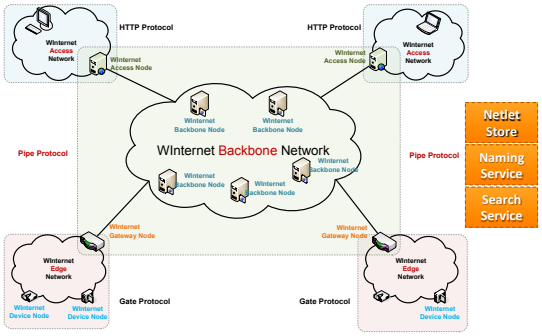
IoT Requirements	Proposal 1	Proposal 2	Proposal 3
1. Real-time	Not good	Possible	Possible
2. Privacy	Not good	Possible	Possible
3. Embedded computing	Impossible	Possible	Possible
4. Scalable	Good	Possible	Good
5. Low cost, quick start	Good	Difficult	Good
6. Marketing and profitable	Not good	Possible	Possible
OVERALL EVALUATION	Infeasible	High risk!	Feasible

Winternet: An Implementation of Proposal 3

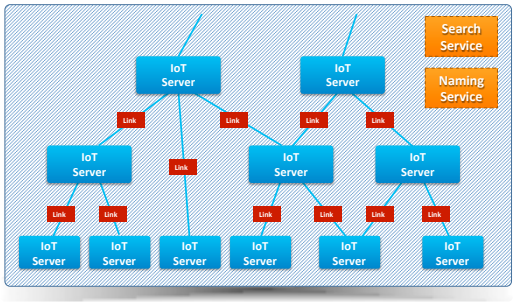
W-Internet



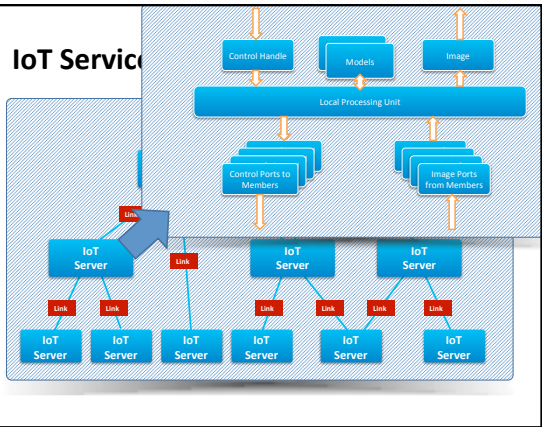
WInternet Architecture



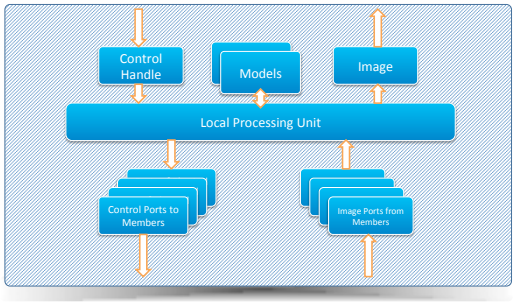
IoT Service Layer: System Structure



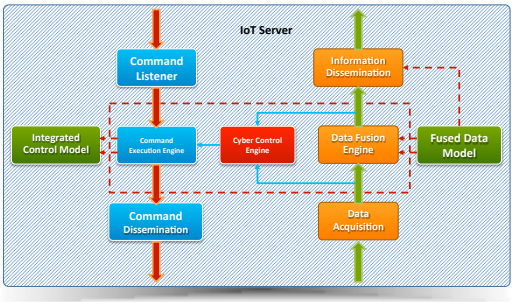
IoT Servic



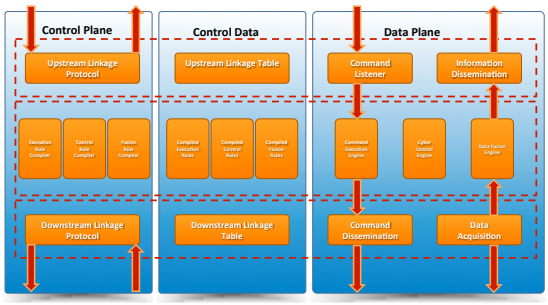
IoT Service Layer: Node Design



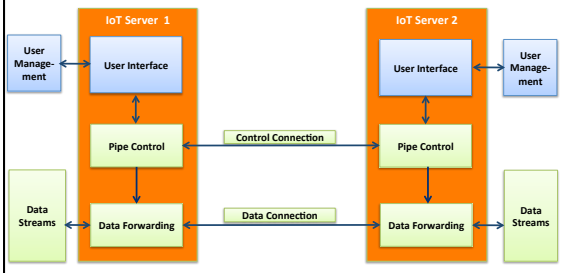
IoT Service Layer: Node Design



IoT Service Layer: Node Design Diagram

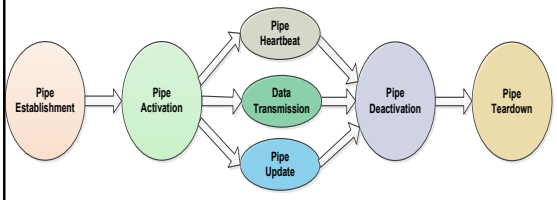


Pipe Protocol



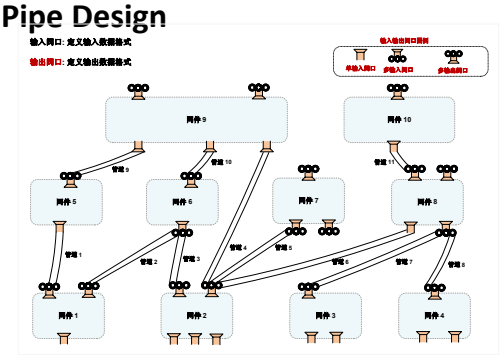
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State Diagram of Pipe Protocol

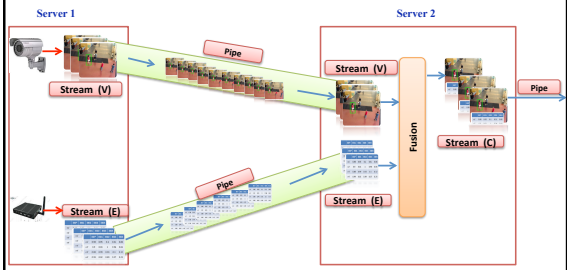


46

Pipe Design



Application Scenario of Pipe Protocol



48

Standard Data Model（DataFrame）

Sensing/Control

Physical objects

	Temperature (License plate #)	Humidity (Vehicle Speed)	Image (Vehicle volume)	...		
Living rm (Intersection 1)						
Guest bdrm (Intersection 2)						
Master bdrm (Intersection3)						
...						

49

Winternet Realization and Demonstration

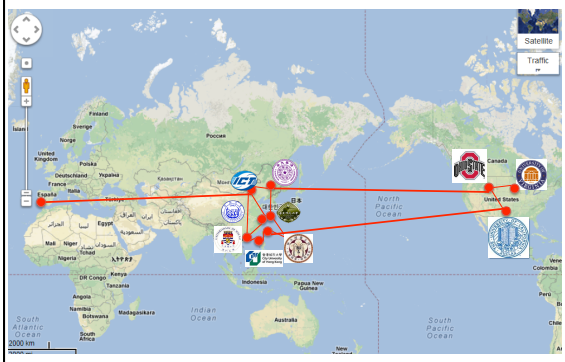
Software in C and Java and supporting Windows、Linux、and embedded Linux



Applied to various equipment

50

Winternet Realization and Demonstration



WHAT are the *existing* APPLICATIONS

showing the promise of IoT



iDigi® Device Cloud™

The iDigi® Device Cloud™ allows users to connect a physical device to the cloud and use an online Web application for remote access. The application converts complex device data into simple and useful information for anyone — from business owners who want to get message when refrigerator temperatures fall below a specific threshold to farmers who want to measure soil quality. iDigi also creates Internet of ANYThings content on their community site.

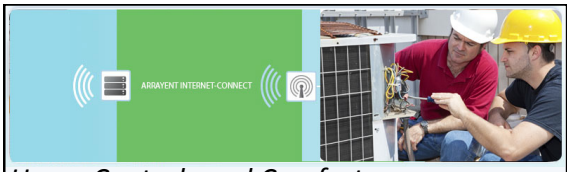




Arrayent is a B2B company, internet-connecting consumer products (i.e. thermostats, security systems, toys, healthcare products) to smartphones, tablets, & web browsers.

ARRAYENT
THE PLATFORM FOR CONNECTED PRODUCTS

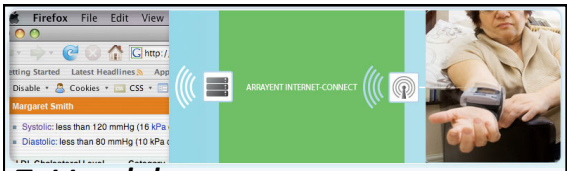
PENTAIR BROADCOM MATTEL Hunter First Alert
Whirlpool LiftMaster SALUS CONTROLS PLC CHAMBERLAIN MICROCHIP



Home Controls and Comfort

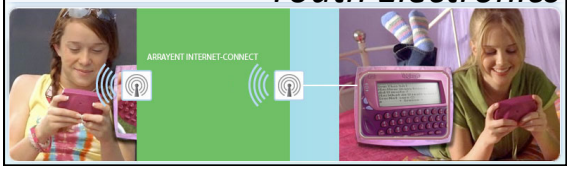
Professionally Installed





E-Health

Youth Electronics



open source

SOFTWARE



THINGSPEAK
ThingSpeak is an open source "Internet of Things" application and API to store and retrieve data from things using HTTP over the Internet or via a Local Area Network. With ThingSpeak, you can create sensor logging applications, location tracking applications, and a social network of things with status updates.

NIMBITS
Nimbits is an open source data server built on cloud computing architecture that provides connectivity among devices using data points.

TOOLS FOR THE OPEN SOURCE INTERNET OF THINGS



IOT TOOLKIT
The IoT Toolkit is an Open Source project to develop a set of tools for building multi-protocol IoT Gateways and Service gateways that enable horizontal co-operation among multiple different protocols and cloud services. The project consists of the Smart Object API, gateway service, and related tools:.

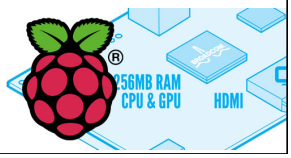
open source

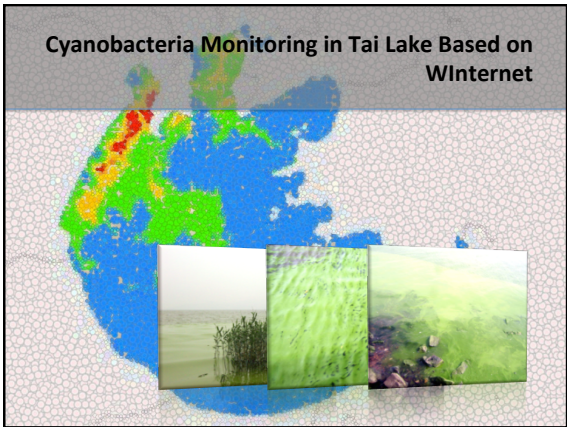
HARDWARE

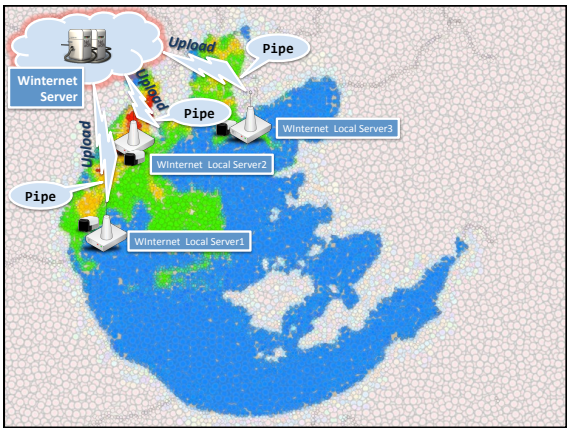


ARDUINO
Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments and features a wide range of ways to connect to the Internet

RASPBERRY PI
The Raspberry Pi is a credit-card-sized single-board computer developed in the UK by the Raspberry Pi Foundation with the intention of stimulating the teaching of basic computer science in schools. The Model B has 2 USB ports and an Ethernet port that can be used for connectivity.







Traffic Monitoring and Control

- **Winternet Device Node** Place camera and other sensing devices to recognize each passing vehicle and its features

Pipe Protocol

- **Winternet Gateway Node** Compute vehicle volume and average speed

Pipe Protocol

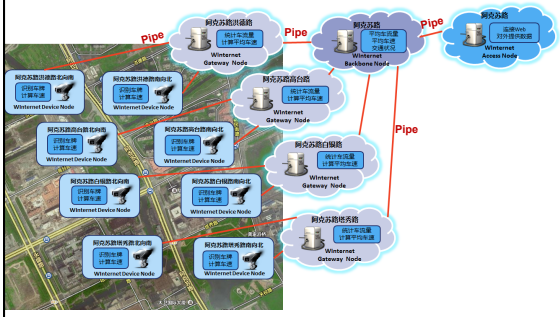
- **Winternet Backbone Node** Compute average vehicle volume and average speed in multiple lanes

Pipe Protocol

- **Winternet Access Node** Link to the backbone network, Internet and Web to provide data to various kinds of users

62

Traffic Control Architecture via WInternet (Akesu Rd., Shanghai)



63











Questions?