
Presented by Tian Wang
Huaqiao University, Xiamen, Fujian
2015/12/26
Outline

- Fog Computing
- Fog in Wireless Sensor Networks
- Applications
- Open Issues
Internet of Things (IoT)

- Connect both inanimate and living things
- Use sensors for data collection
- Everything have a digital identity and connectivity
Impact of IoT

• **By 2020:**
  - 50 billion connected things
  - 40 or 50 trillion GB data

• **How to deal with them?**
IoT and The Cloud

• Cloud Computing:
  − Connect all things to the Cloud
  − Provide management, storage and computing services and applications
Problems in the Cloud

• Communication bottleneck
  − Some devices don’t have enough high bandwidth, especially for cell phones, tablets and other portable devices

• Low real-time
  − The cloud is actually deployed far away from connected devices, which means a long-distance communication through unstable networks with low real-time response

• Security risks
  − The cloud is a centralized center with all data together and designed to be convenient for various connection, which becomes vulnerable for attackers
The Fog Framework

- **The Fog:**
  - A intermediate layer between the cloud and end devices
  - Provides storage and computing services in short distance
Fog Computing

- An architecture that uses one or a collaborative multitude of end-user clients or near-user edge devices to carry out a substantial amount of storage (rather than stored primarily in cloud data centers), communication (rather than routed over the internet backbone), and control, configuration, measurement and management.
Features of Fog Computing

- Edge location, location awareness and low latency
- Geographical distribution
- Compatibility with various end devices
- Support for mobility and wirelesses
- Real-time interactions
- Heterogeneity
Other Computing Patterns

- **Edge Computing** pushes applications, data, and services away from centralized nodes to the logical extremes of a network, leveraging resources that may not be continuously connected to a network such as laptops, smartphones, tablets and sensors.

- **Grid Computing** is a form of distributed computing whereby a “super virtual computer” is composed of many networked loosely coupled computers acting together to perform large tasks. It is the collection of computer resources from multiple locations to reach a common goal.

- **Fog Computing** is a kind of extension about cloud computing and based on the cloud, which is different from local computing or grid computing that can be independent with the cloud.
Smart Grid

- The fog process the data generated by grid sensors and devices and send control commands to actuators.
- The fog can implement energy load balancing applications to switch alternative energies automatically.
Smart Traffic Lights

• The fog interacts locally with sensors, detects presence of pedestrian and bikers and measures the distance and speed of approaching vehicles
• According to video camera, the fog can automatically change street lights to open lanes for an ambulance to pass by
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Fog Computing

Fog in Wireless Sensor Networks

Applications

Open Issues
Wireless Sensor Networks (WSNs)

- **Sensors:**
  - Generates a lot of data from surrounding environment
  - Limited in sources and abilities such as energy, computing and storage
Sensor-Cloud architecture is an integration of cloud computing and WSNs. The cloud provides vast storage capacity and processing capabilities, enabling collecting the huge amount of sensor data by the gateways on both sides.
Problems in Sensor-Cloud

• Communication burden
  – Sensors are limited in energy as well as communication ability with a low bandwidth
• Weak real-time
  – The cloud cannot respond to sensors’ real-time requests in some scenarios
• Low dependability
  – Sensors are inclined to faults with unstable connection and inaccuracy data
• Security problem
  – Data from sensors and in the cloud are all vulnerable
Advantages of the Fog in WSNs

• Efficient connectivity
  − The fog can be deployed closely to the WSNs and even has a direct connection to them

• High dependability
  − The fog can adjust transmission burden and cycle duty of sensors in order to optimize their energy efficiency and even recover data

• High real-time
  − The fog is close to WSNs and is able to response immediately to sensors' real-time requests

• Strong Security
  − The fog can use strong encryption towards connections to the cloud
Forest Fire Alarm

- **High real-time:**
  - Fog nodes can respond to fire detection in real-time
  - Fog nodes will turn on extinguishers (actuators) automatically
Airplane Operation Data

- **Local data storage and process:**
  - 10TB data per half hour by sensors during flight
  - The fog process data and provide emergency measures services
Structural Health Moniting

- High dependability:
  - Fog devices can detect corrupt results by fault sensors
  - The fog will recover those wrong diagnosis
Train Self-Maintain

- **Self-maintaining system:**
  - The fog stores data from sensor which are on train's ball-bearing and detect heat levels
  - The fog alert the train operator to stop the train for emergency
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Researches and Open Issues

- Data transmission methods
- Fog devices cooperation
- Dependability awareness
- Security insurance
Data transmission methods

• The communication ability of one single sink in WSNs is limited
• When many data come into one sink at the same time, they will suffer from upload delay
• A mobile fog node can serve as a mobile sink where data can be fused and compressed before uploading
• Several mobile fog nodes can build up a multi-input multi-output (MIMO) network for load balance
Data Transmission Maximizing

- Mobile MIMO networks:
  - Dynamic adjustment
Fog Devices Cooperation

• Several fog devices should cooperate together to guarantee the quality of service (QoS) and improve network performance

• Swarm intelligence method can be used to optimize services and even to modify physical motion of mobile fog devices
Fog Devices Dispatch

- **Mobile fog nodes:**
  - Cooperation by swarm intelligence
Dependability Awareness

- Sensors are inclined to faults, such as energy outage, connection break, program halt and wrong decision
- Fault sensors can corrupt results of a abnormal event and make it without being detected
- Possible solutions in the fog:
  - Fault detection methods
  - Simple prediction and recovery of data
  - Duty cycle optimization for underlying sensors
Security Insurance

- Convenient accessibility of the cloud raises security risks at the same time
- Sensors fall short in strong encryption methods for communication with the cloud
- The fog storage can distribute data among the fog and the cloud in order to improve security
- The fog can establish strong encrypted connection with the cloud
Conclusions

- Internet of things and cloud computing can be mutually beneficial
- Fog computing is a significant extension for cloud computing and wireless sensor networks
- The fog framework can be used in many scenarios and applications
- There are also some open issues for future research
Thanks

Tian Wang
国立华侨大学
Email: wangtian@hqu.edu.cn
2015/12/26
References


References

