IIT KHARAGPUR

NPTEL ONLINE CERTIFICATION COURSES

NPTEL

Cloud Computing - Practical

Dr. Sudip Misra
Associate Professor
Department of Computer Science and Technology
IIT Kharagpur
Email: smisra@sit.iitkgp.ernet.in
Website: http://cse.iitkgp.ac.in/~smisra/

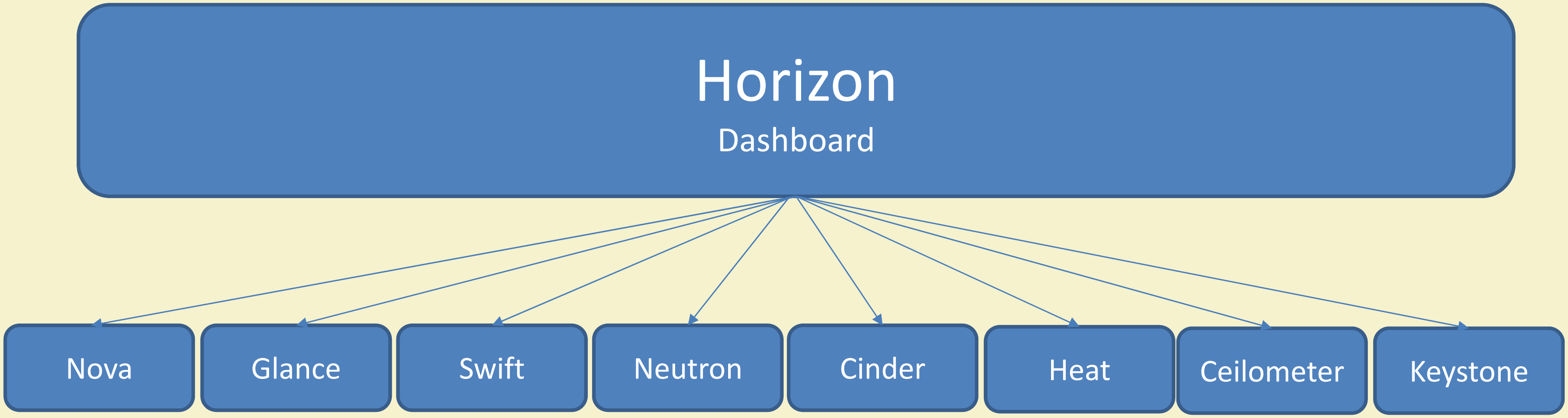
Contents

- ✓ Introduction to Openstack
- ✓ Components
- ✓ Installation
- ✓ Creating a key-pair and manage security group
- ✓ Launce Instances
- ✓ Creating an image
- ✓ Accessing and Communicating with instances

Introduction to Openstack

- ✓ A software to create a cloud unfrastructure
- ✓ Launched as a joint project of Rackspace Hosting and NASA in 2010
- ✓ Opensource
- ✓ Presently many companies are contributing to openstack
- ✓ Eg. IBM, CISCO, HP, Dell, Vmware, Redhat, suse, Rackspace hosting
- ✓ It has a very large community
- ✓ Can be used to develop private cloud or public cloud
- ✓ Versions:
  - ✓ Austin, Bexar, Cactus, Diablo, Essex, Folsom, Grizzly, Havana, Icehouse, Juno, Kilo, Liberty, Mitaka, Newton, Ocata (Latest)

Components


Horizon
Dashboard
Nova
Glance
Swift
Neutron
Cinder
Heat
Ceilometer
Keystone

Components contd.

- ✓ Keystone
  - ✓ Identity service
  - ✓ Provides authentication and authorization

- ✓ Horizon
  - ✓ Dashboard
  - ✓ GUI of the software
  - ✓ Provides overview of the other components

Components contd.

- ✓ Nova
  - ✓ Compute service
  - ✓ Where you launce your instances

- ✓ Glance
  - ✓ Image service
  - ✓ Discovering, registering, retrieving the VM
  - ✓ Snapshots

Components contd.

- ✓ Swift
  - ✓ Object storage
  - ✓ Helps in storing data safely, cheaply and efficiently

- ✓ Neutron
  - ✓ Provides networking service
  - ✓ Enables the other services to communicate with each other
  - ✓ Make your own network

Components contd.

- ✓ Cinder
  - ✓ Block storage
  - ✓ Virtualizes the management of block service
- ✓ Heat
  - ✓ Orchestration
- ✓ Ceilometer
  - ✓ Billing
  - ✓ What service you are using
  - ✓ How long are you using

Installation

- ✓ Can be installed manually or using scripts like Devstack
- ✓ We will use devstack
- ✓ Steps:
  - Install git (sudo apt-get install git)
  - Clone devstack (git clone https://git.openstack.org/openstack-dev/devstack)
  - Go to devstack directory (cd devstack)

Installation contd.

- Open local.conf file and paste the following and save the file

  ADMIN_PASSWORD=<YOUR PASSWORD>

  DATABASE_PASSWORD =<YOUR PASSWORD>

  RABBIT_PASSWORD =<YOUR PASSWORD>

  SERVICE_PASSWORD =<YOUR PASSWORD>

  HOST_IP=<the IP of your PC>

- Run the stack.sh file (./stack.sh)
- For uninstallation, go to devstack directory and run unstack.sh file

References

- ✓ 1. https://www.openstack.org/
- ✓ https://docs.openstack.org/developer/devstack/

Thank you

IIT KHARAGPUR

NPTEL ONLINE CERTIFICATION COURSES

NPTEL

Sensor-Cloud-Part I

Sensor-as-a-Service

Dr. Sudip Misra

Associate Professor

Department of Computer Science and Engineering

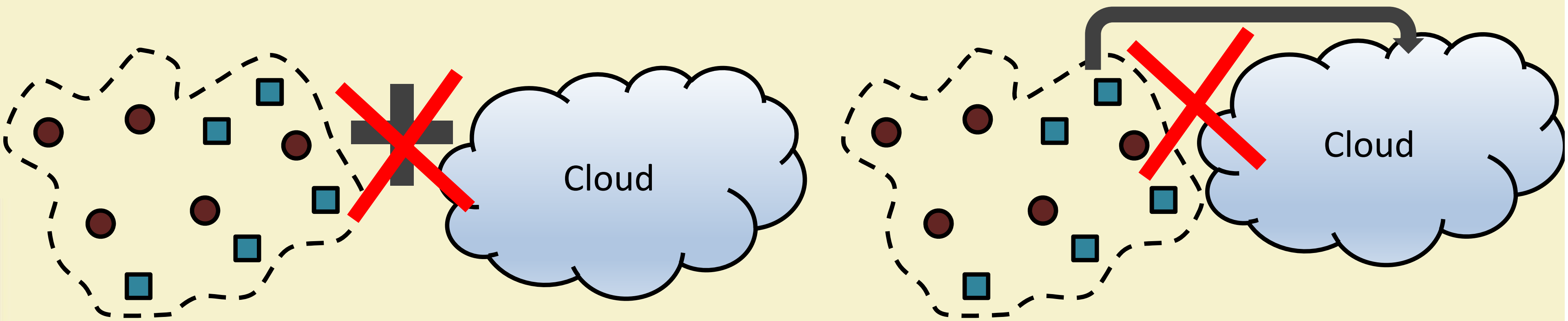
IIT Kharagpur

Email: smisra@sit.iitkgp.ernet.in

Website: http://cse.iitkgp.ac.in/~smisra/

Introduction

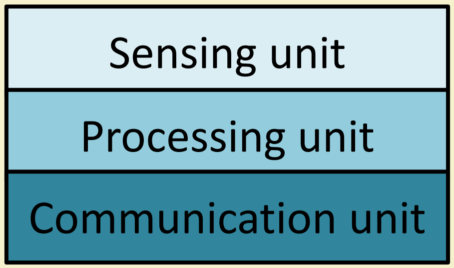
- ✓ It is not mere integration of sensors and cloud computing
- ✓ It is not only “dumping the sensor data into cloud”



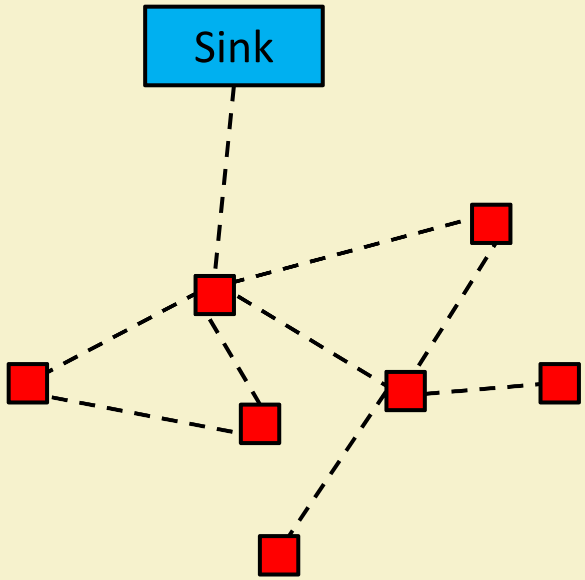
Wireless Sensor Networks (WSNs): Recap

- ✓ Contain sensor nodes which sense some physical phenomena from the environment
- ✓ Transmit the sensed data (through wireless communication) to a centralized unit, commonly known as Sink node
- ✓ The communication between Sink node and other sensor nodes in the network may be single/multi-hop
- ✓ Sink node further process data

Wireless Sensor Networks (WSNs): Recap



Major Components of a Sensor Node



Wireless Sensor Networks

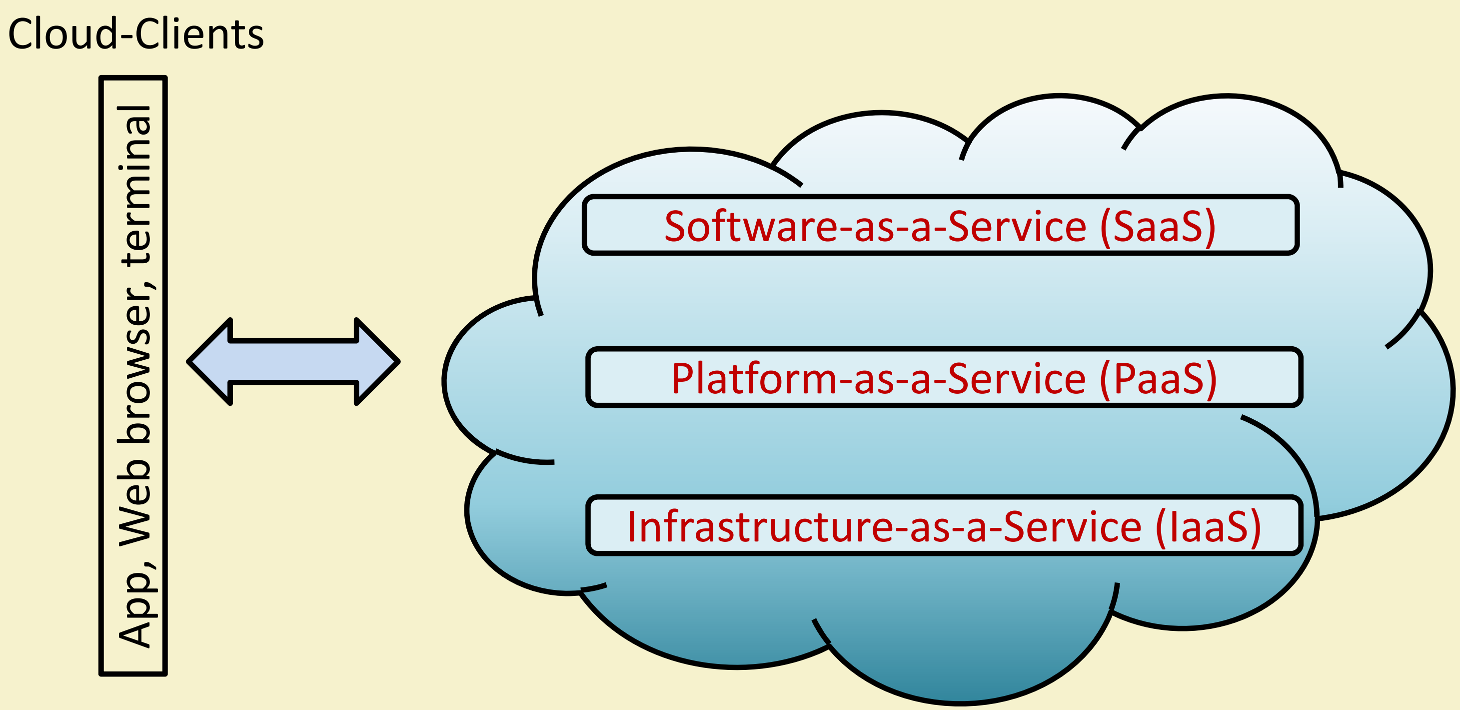
Applications

- ✓ Target Tracking
- ✓ Wildlife Monitoring
- ✓ Healthcare
- ✓ Industrial Applications
- ✓ Smart Home
- ✓ Smart City
- ✓ Agriculture
- ✓ …

Cloud Computing: Recap

- ✓ An architecture which provides on-demand computing resources
- ✓ Advantages
  - ✓ Elasticity: Scaling up/down
  - ✓ Pay-per-use: Payment for the resource as per requirement
  - ✓ Self Service: Resource can be accessed by self

Cloud Computing: Services



Cloud Computing: Services

- ✓ Software-as-a-Service (SaaS)
  - ✓ A third party provides a host application over internet
  - ✓ Example: Microsoft Office 365
- ✓ Platform-as-a-Service (PaaS)
  - ✓ Provide a platform to develop and run applications
  - ✓ Example: Windows Azure
- ✓ Infrastructure-as-a-Service (IaaS)
  - ✓ Provide computing resources
  - ✓ Example: Storage space

Virtualization Concept

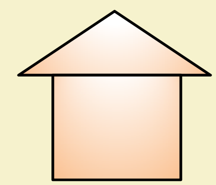
- One computer host appears as many computers-concept of Virtual Machine (VM)
- Improve IT throughput and costs by using physical resources as a pool from which virtual resources can be allocated.
- Benefit
  - Sharing of resources: Same resource can be shared, in turn cost reduction
  - Encapsulation: A complete computing environment
  - Independence: Runs independently of underlying hardware
  - Portability: VM Migration

Limitations of WSNs

- ✓ Procurement
  - ✓ Price
  - ✓ Right vendor
  - ✓ Types of sensor integrated with it
- ✓ Deployment
  - ✓ Right way of deployment
  - ✓ Right place of deployment
- ✓ Maintenance
  - ✓ Post deployment maintenance
  - ✓ Battery lifetime

Change of Requirement

An example

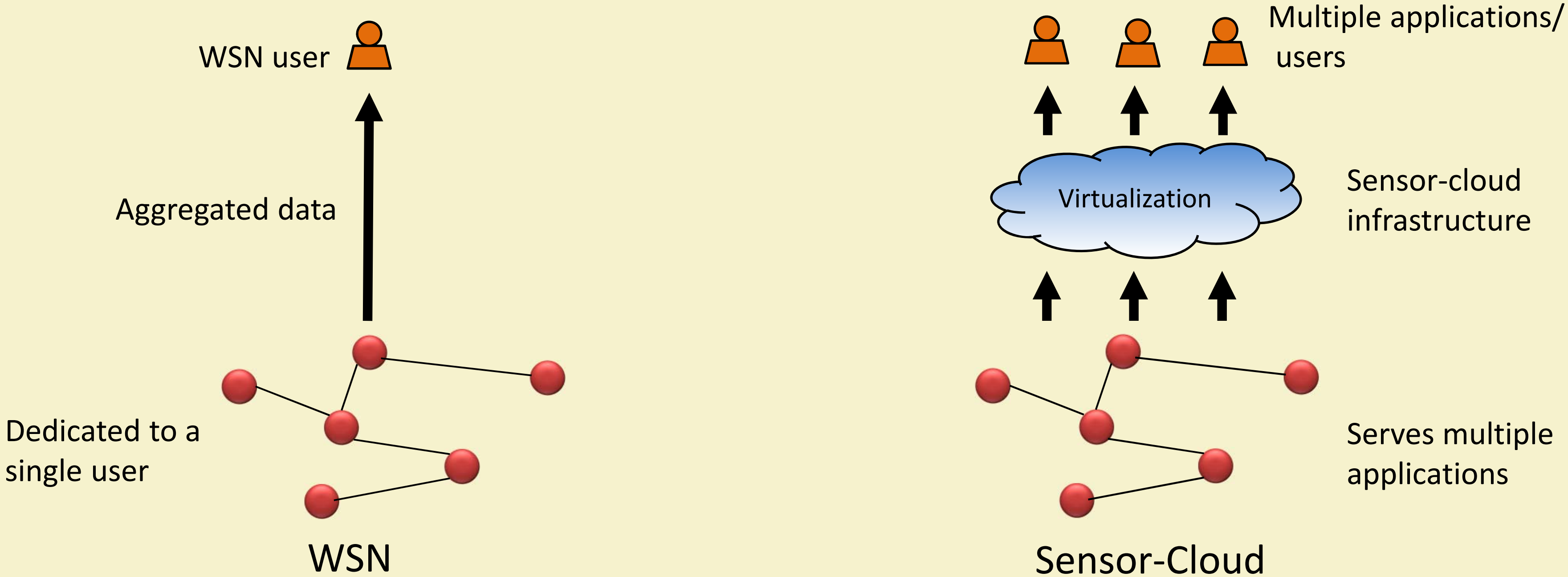
Today	Tomorrow
 Agriculture	 Smart Home

Result: Change in Sensor type, deployment area, topology design, and many more….

Sensor-Cloud: Introduction

- ✓ Not only the mere integration of cloud computing and sensor networks, but sensor-cloud is more than that
- ✓ Concept of virtualization of sensor node
- ✓ Pay-per-use
- ✓ One sensor node/network appears as many
- ✓ A stratum between sensor nodes and end-users

Difference with WSN



Source: S. Misra; S. Chatterjee; M. S. Obaidat, "On Theoretical Modeling of Sensor Cloud: A Paradigm Shift From Wireless Sensor Network," in *IEEE Systems Journal* , vol.PP, no.99, pp.1-10

Difference with WSN (Contd.)

Actors and Roles		
Attributes	**WSN**	**Sensor Cloud**
Ownership	WSN-user	Sensor-owner
Deployment	WSN-user	Sensor-owner
Redeployment	WSN-user	SCSP
Maintenances	WSN-user	SCSP
Overhead	WSN-user	SCSP
Usage	WSN-user	End-user

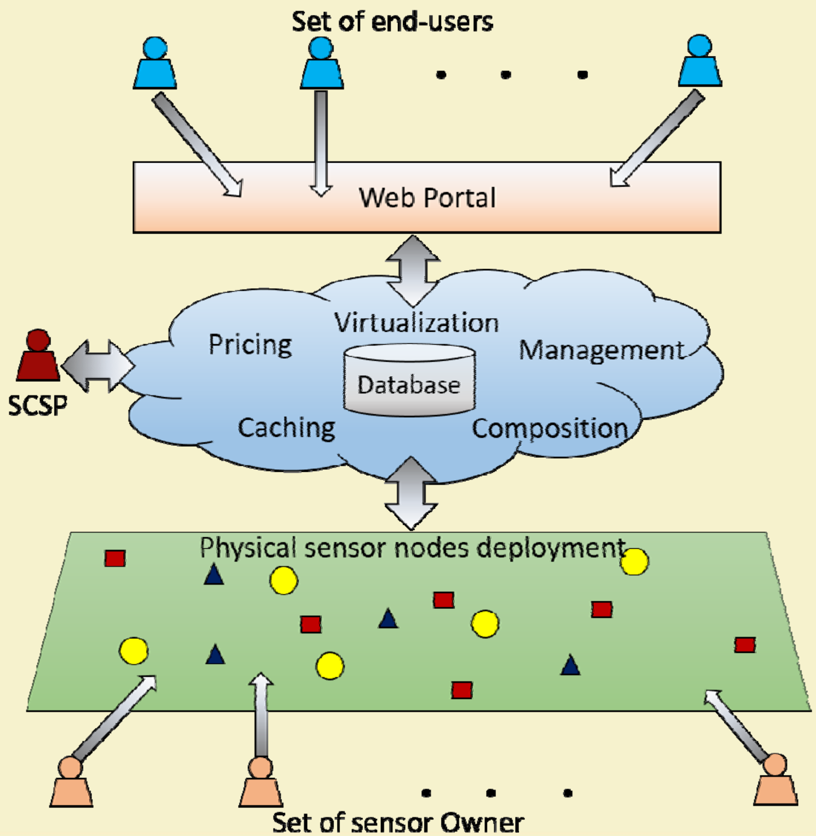
Source: S. Misra; S. Chatterjee; M. S. Obaidat, "On Theoretical Modeling of Sensor Cloud: A Paradigm Shift From Wireless Sensor Network," in *IEEE Systems Journal* , vol.PP, no.99, pp.1-10

Actors in Sensor-cloud

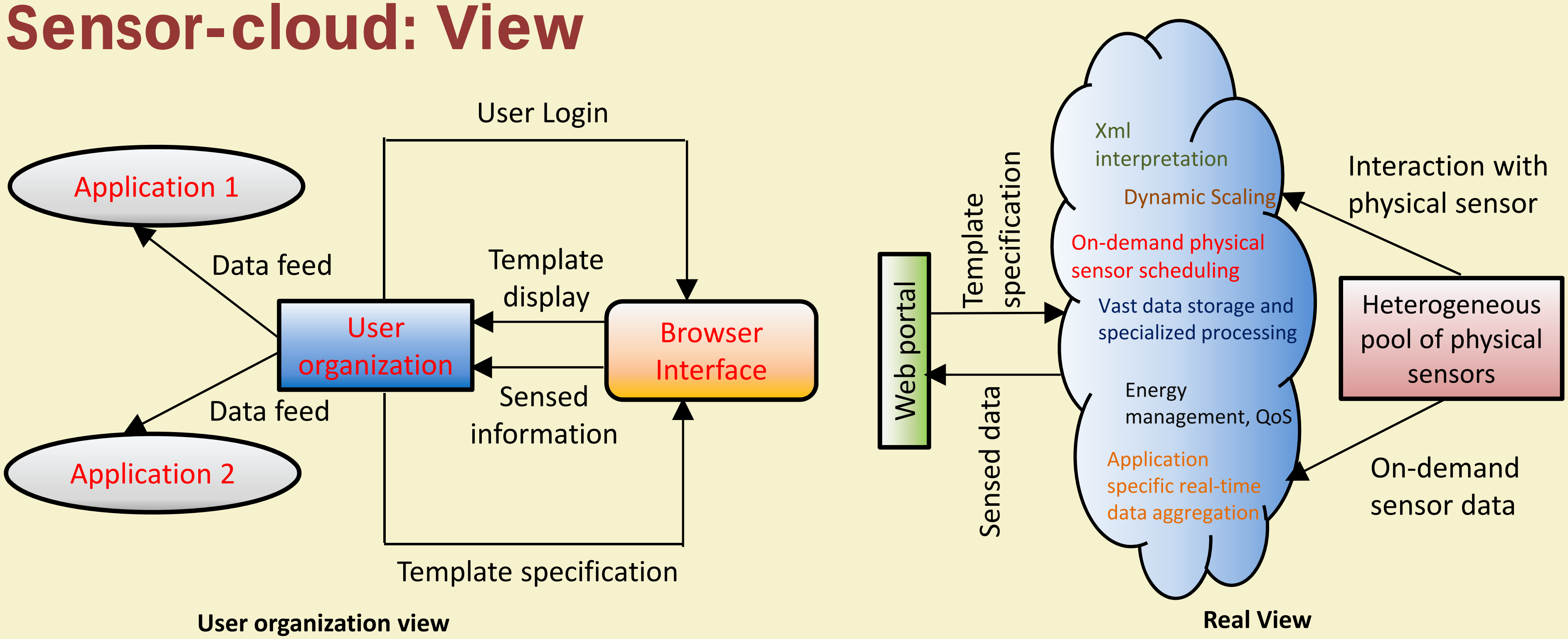
- ✓ End-users
  - ✓ Enjoy Se-aaS through applications as per the requirements.
  - ✓ Unknown about what and which physical sensor is/are allocated to serve the application
- ✓ Sensor-owner
  - ✓ Plays a role from business perspective.
  - ✓ They purchase physical sensor devices, deployed over different geographical locations, and lend these devices to the sensor-cloud
- ✓ Sensor-Cloud Service Provider (SCSP)
  - ✓ A business actor.
  - ✓ SCSP charges price from the end-users as per their usage of Se-aaS.

Sensor-cloud: Architecture

- ✓ End-users: Registered themselves, selects templates, and request for application(s)
- ✓ Sensor-owner: Deploy heterogeneous/ homogeneous physical sensor nodes over different geographical location
- ✓ SCSP: Plays managerial role



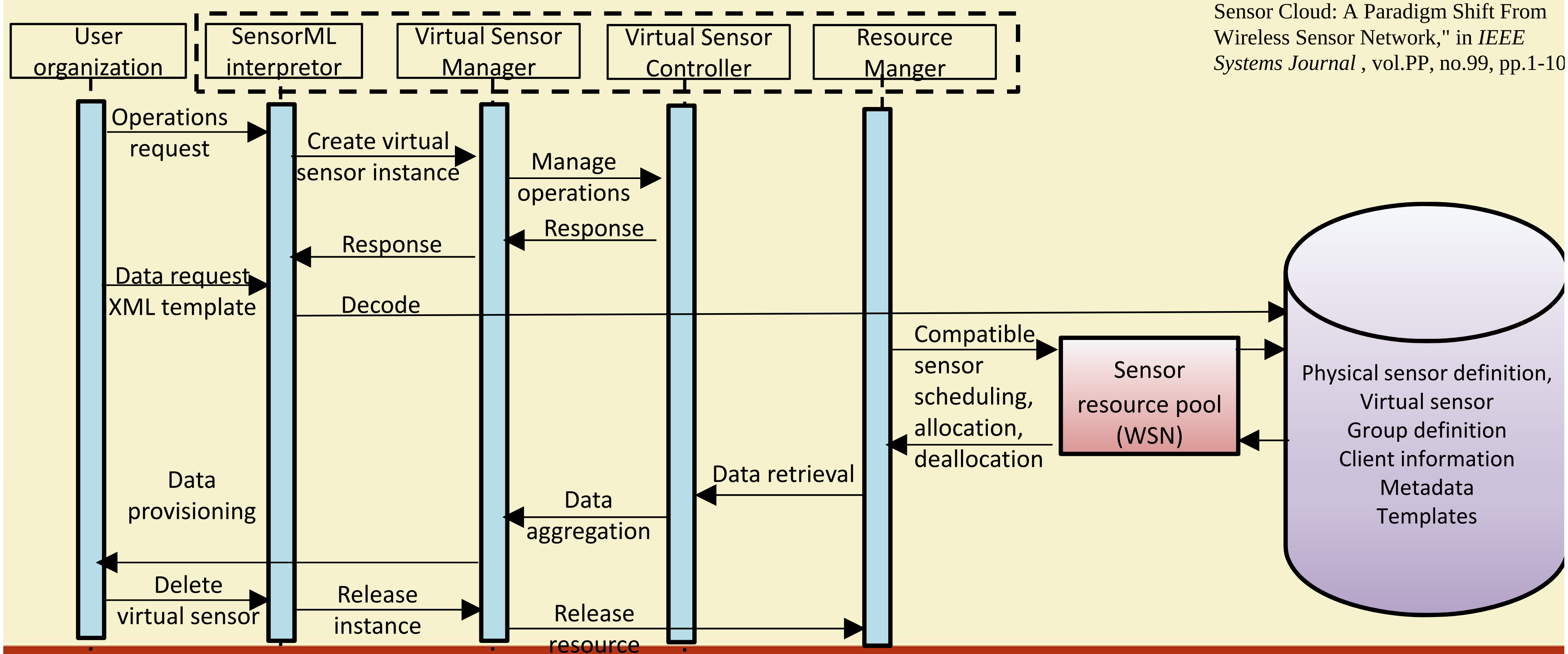
Sensor-cloud: View



Source: S. Misra; S. Chatterjee; M. S. Obaidat, "On Theoretical Modeling of Sensor Cloud: A Paradigm Shift From Wireless Sensor Network," in *IEEE Systems Journal* , vol.PP, no.99, pp.1-10

Work Flow of Sensor-Cloud

Source: S. Misra; S. Chatterjee; M. S. Obaidat, "On Theoretical Modeling of Sensor Cloud: A Paradigm Shift From Wireless Sensor Network," in *IEEE Systems Journal* , vol.PP, no.99, pp.1-10



Case Study: Target Tracking

"We consider a WSN-based target tracking application, in which a WSN owner refuses to share the sensed information with an external body, even in exchange of money. Consequently, any organization that wishes to detect intrusion within a particular zone has to deploy its own WSN. This leads to a long-term investment due to costly network setup and maintenance overheads. However, in a sensor-cloud environment, the same organization can use the same tracking application and still get the service without actually owning the WSN"

Source: S. Misra; S. Chatterjee; M. S. Obaidat, "On Theoretical Modeling of Sensor Cloud: A Paradigm Shift From Wireless Sensor Network," in *IEEE Systems Journal* , vol.PP, no.99, pp.1-10

Thank You!!

IIT KHARAGPUR

NPTEL ONLINE CERTIFICATION COURSES

NPTEL

Sensor-Cloud-Part II

Sensor-as-a-Service

Dr. Sudip Misra

Associate Professor

Department of Computer Science and Engineering

IIT Kharagpur

Email: smisra@sit.iitkgp.ernet.in

Website: http://cse.iitkgp.ac.in/~smisra/

Management Issues in Sensor-Cloud

- ✓ Optimal Composition of virtual sensor nodes
- ✓ Data Caching
- ✓ Optimal Pricing

Optimal Composition of Virtual Sensor

Source: S. Chatterjee and S. Misra, "Dynamic Optimal Composition of a Virtual Sensor for Efficient Virtualization Within Sensor-cloud", IEEE ICC 2015.

Introduction

- ✓ Efficient virtualization of the physical sensor nodes
- ✓ An optimal composition of VSs
- ✓ Consider same geographic region: CoV-I
- ✓ Spanning across multiple regions: CoV-II

Source: S. Chatterjee and S. Misra, "Dynamic Optimal Composition of a Virtual Sensor for Efficient Virtualization Within Sensor-cloud", IEEE ICC 2015.

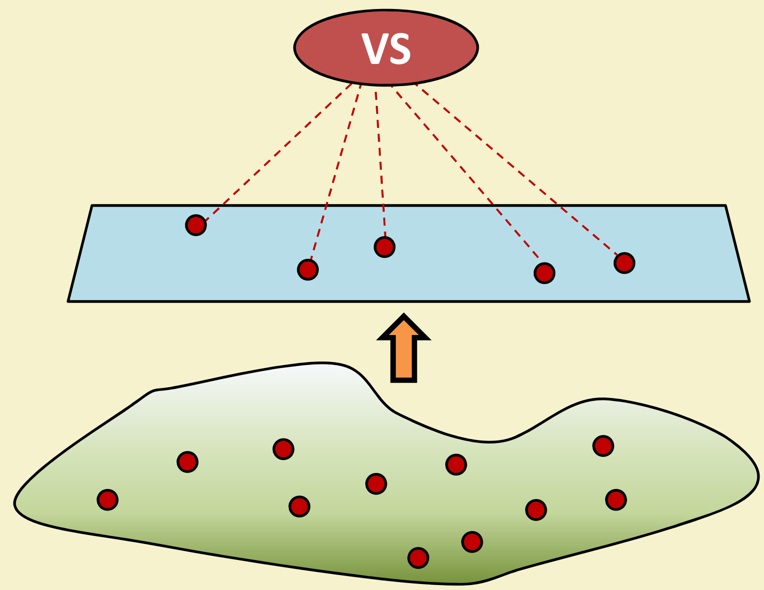
Why Composition of Virtual Sensor?

- ✓ Resource-constrained sensor nodes
- ✓ Dynamic change in sensor conditions
- ✓ The composition of virtual sensors are non-traditional

Source: S. Chatterjee and S. Misra, "Dynamic Optimal Composition of a Virtual Sensor for Efficient Virtualization Within Sensor-cloud", IEEE ICC 2015.

CoV-I: Formation of Virtual Sensor

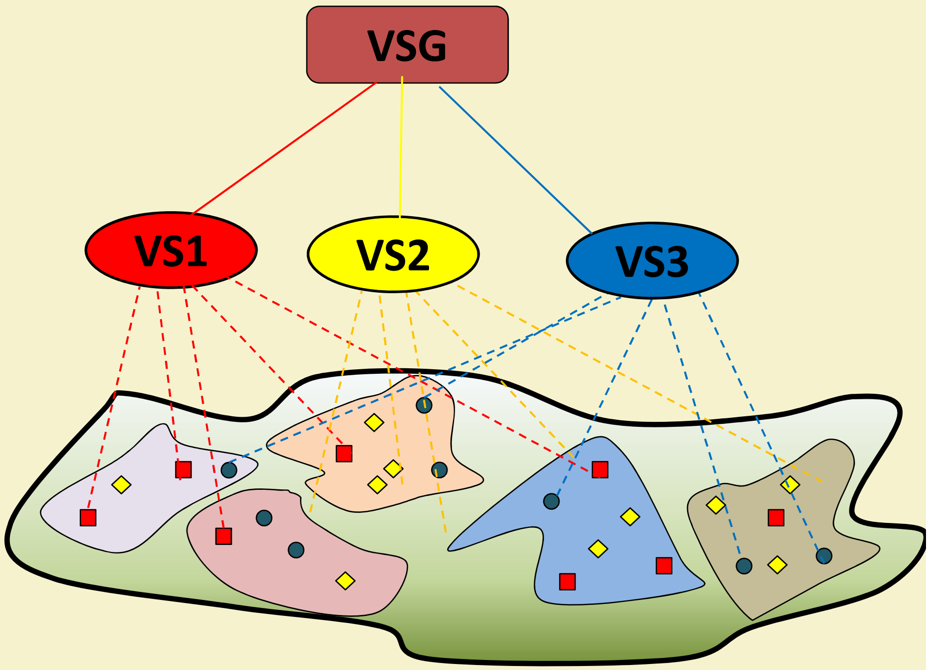
- ✓ Optimal formation of Virtual Sensor (VS)
- ✓ Homogeneous sensor nodes within same geographical boundary



Source: S. Chatterjee and S. Misra, "Optimal composition of a virtual sensor for efficient virtualization within sensor-cloud," 2015 IEEE International Conference on Communications (ICC), London, 2015, pp. 448-453

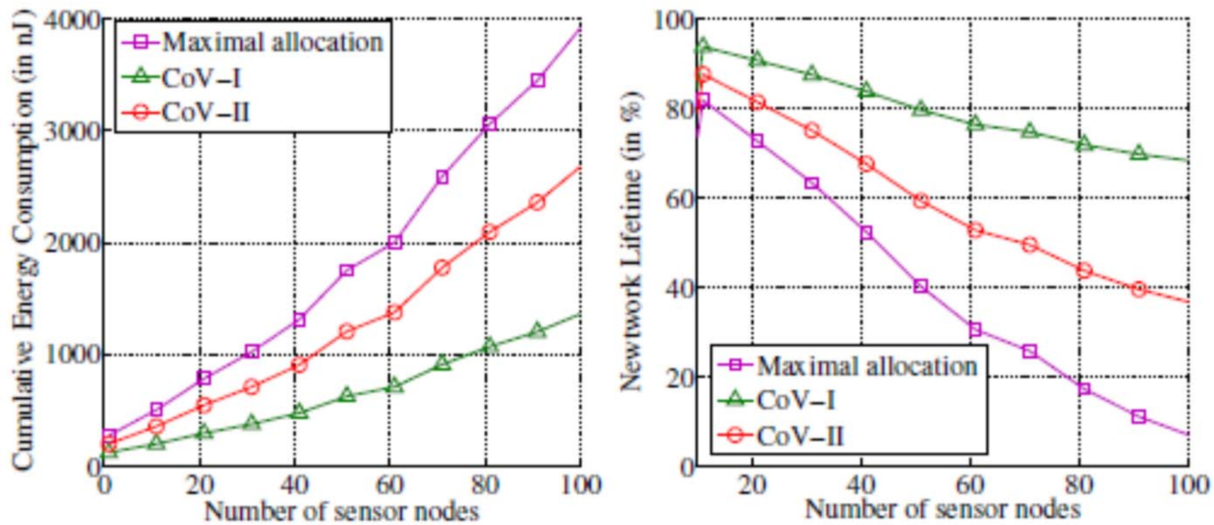
CoV-II: Formation of Virtual Sensor Group

- ✓ Formation of Virtual Sensor Group (VSG)
- ✓ Heterogeneous physical sensor nodes across different geographical locations



Source: S. Chatterjee and S. Misra, "Optimal composition of a virtual sensor for efficient virtualization within sensor-cloud," 2015 IEEE International Conference on Communications (ICC), London, 2015, pp. 448-453

Performance



(a) Study of cumulative energy consumption (b) Study of network lifetime

Source: S. Chatterjee and S. Misra, "Optimal composition of a virtual sensor for efficient virtualization within sensor-cloud," 2015 IEEE International Conference on Communications (ICC), London, 2015, pp. 448-453

Dynamic and Adaptive Data Caching Mechanism

Source: S. Chatterjee, S. Misra, “Dynamic and Adaptive Data Caching Mechanism for Virtualization within Sensor-Cloud”, IEEE ANTS 2014.

Introduction

- ✓ Introduces internal and external caching mechanisms
- ✓ Ensures efficiency in resource utilization
- ✓ Flexible with the varied rate of change of the physical environment

Source: S. Chatterjee, S. Misra, "Dynamic and Adaptive Data Caching Mechanism for Virtualization within Sensor-Cloud", IEEE ANTS 2014.

Why Caching in Sensor-Cloud?

- ✓ End-users request for the sensed information through a Web-interface
- ✓ Allocation of physical sensor nodes and virtualization takes place
- ✓ Physical sensor nodes continuously sense and transmit data to sensor-cloud

Source: S. Chatterjee, S. Misra, “Dynamic and Adaptive Data Caching Mechanism for Virtualization within Sensor-Cloud”, IEEE ANTS 2014.

Why Caching in Sensor-Cloud? (Contd.)

- ✓ Practically, in some cases, the change in environmental condition are significantly slow
- ✓ Due to the slow change in environment, the sensed data of physical sensors unaltered
- ✓ In such a situation, unnecessary sensing causes energy consumption

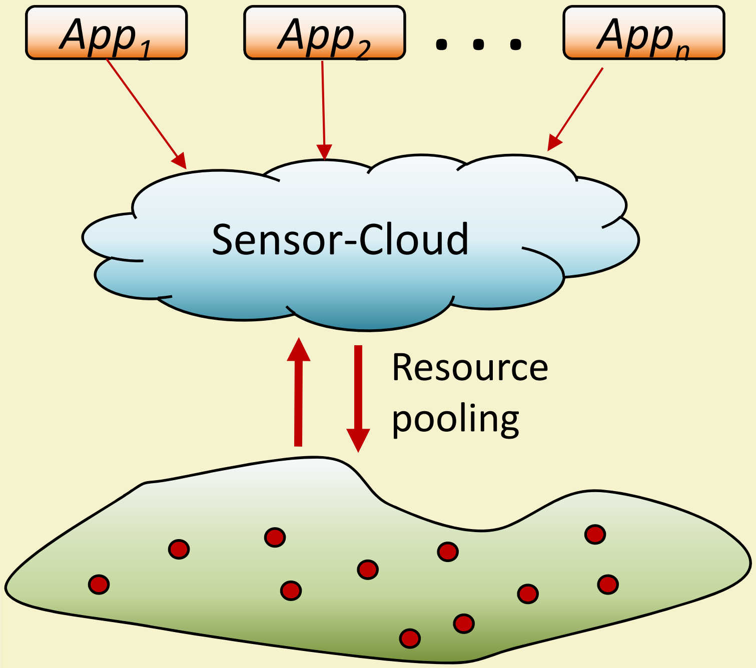
Source: S. Chatterjee, S. Misra, "Dynamic and Adaptive Data Caching Mechanism for Virtualization within Sensor-Cloud", IEEE ANTS 2014.

External and Internal Caching Mechanism

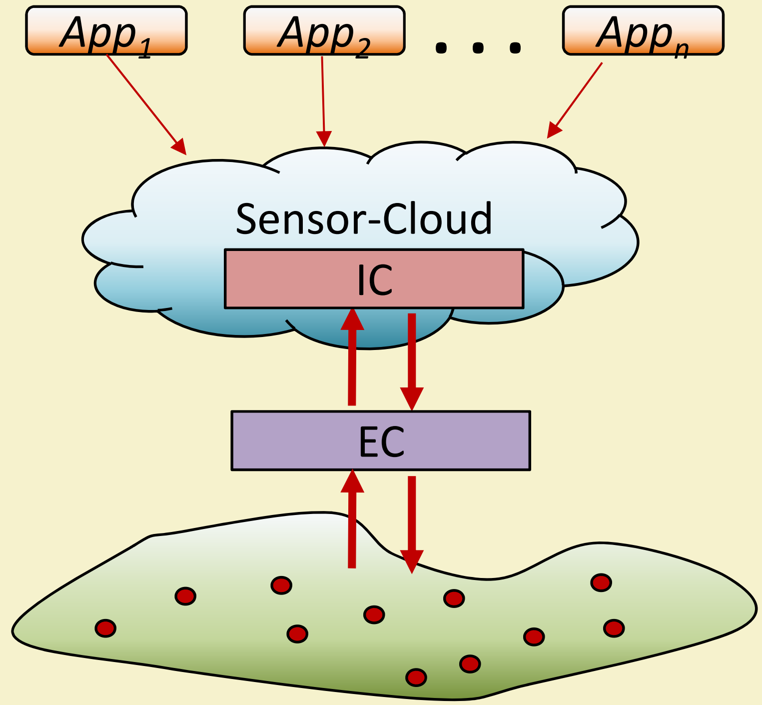
- ✓ Internal Cache (IC)
  - ✓ Handles requests from end-user
  - ✓ Takes decision whether the data should be provided directly to the end user or is it required to re-cache the data from external cache
- ✓ External Cache (EC)
  - ✓ After every certain interval data are required to re-cache
  - ✓ Initially, few data are used to be transmitted to IC

Source: S. Chatterjee, S. Misra, "Dynamic and Adaptive Data Caching Mechanism for Virtualization within Sensor-Cloud", IEEE ANTS 2014.

Architecture of Caching



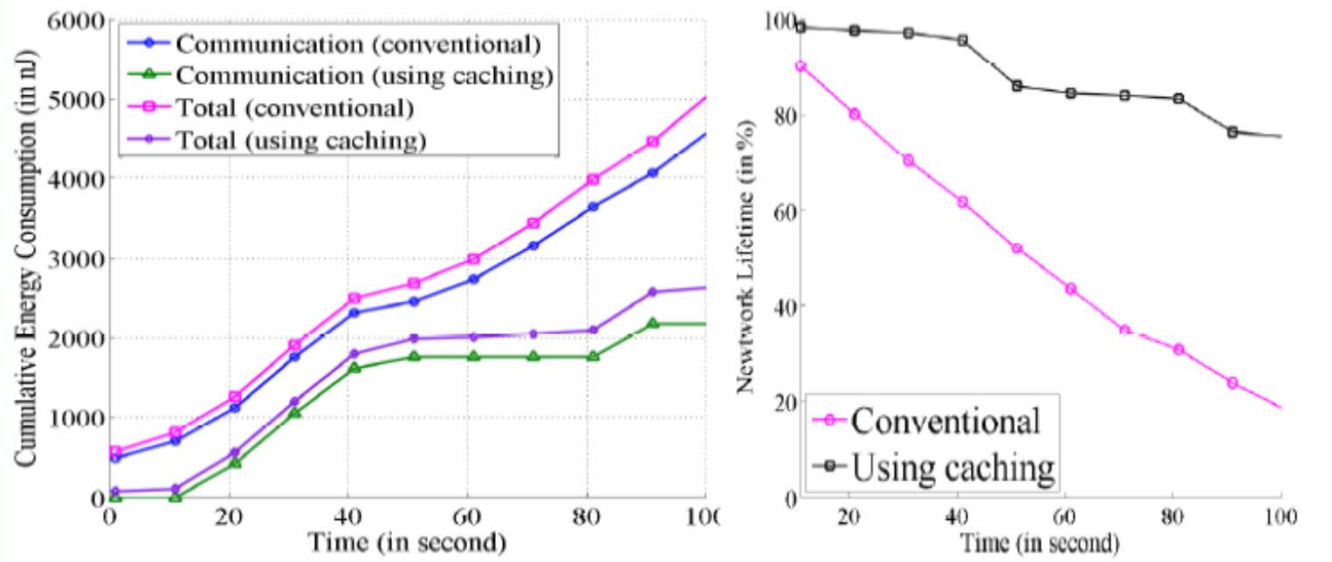
Existing Architecture



Cache-enabled Architecture

Source: S. Chatterjee, S. Misra, "Dynamic and Adaptive Data Caching Mechanism for Virtualization within Sensor-Cloud", IEEE ANTS 2014.

Performance



(a) Analysis of energy efficiency (b) Analysis of network lifetime

Source: S. Chatterjee, S. Misra, "Dynamic and Adaptive Data Caching Mechanism for Virtualization within Sensor-Cloud", IEEE ANTS 2014.

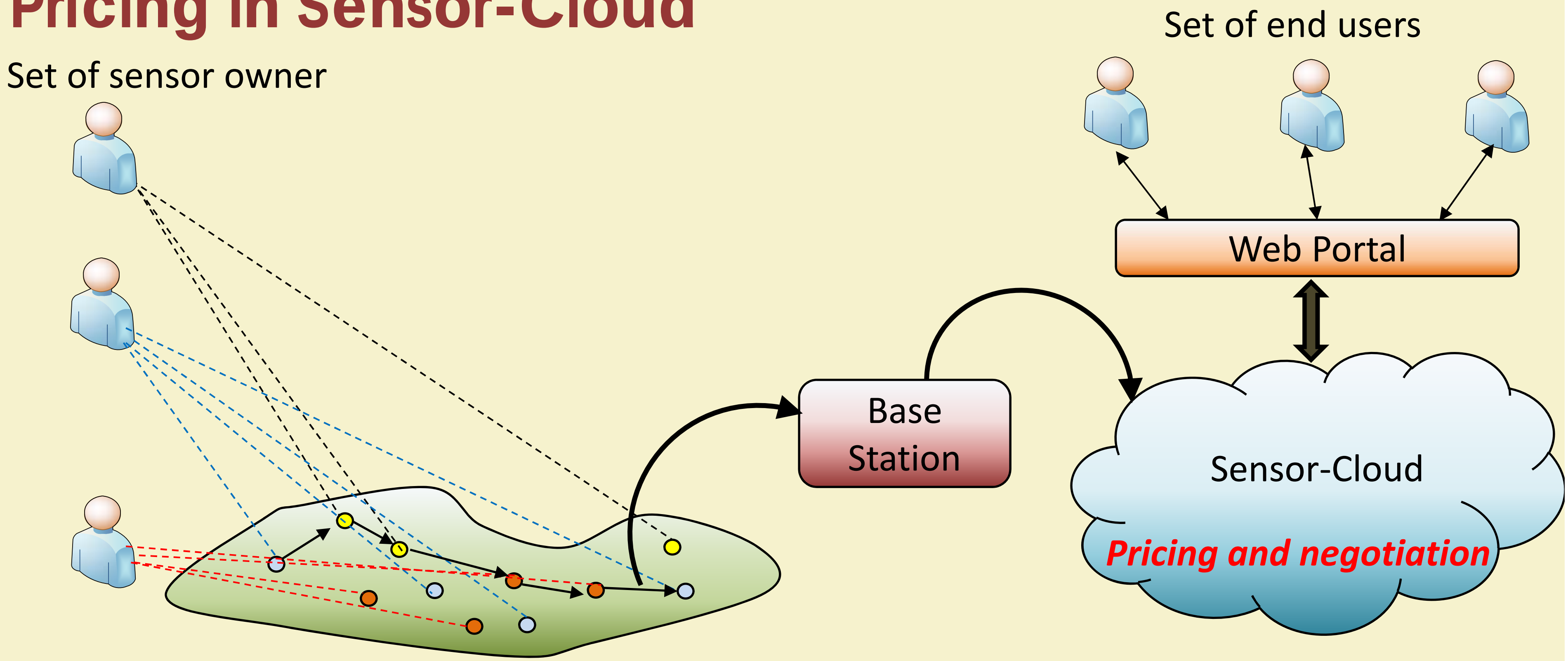
Dynamic Optimal Pricing for Sensor-Cloud Infrastructure

Source: S. Chatterjee, R. Ladia, and S. Misra, “Dynamic Optimal Pricing for Heterogeneous Service-Oriented Architecture of Sensor-Cloud Infrastructure”, IEEE TSC 2017.

Introduction

- ✓ Existing schemes consider homogeneity of service (e.g. for IaaS, SaaS)
- ✓ No scheme for SeaaS.
- ✓ The proposed pricing scheme comprises of two components:
  - ✓ Pricing attributed to hardware (pH)
  - ✓ Pricing attributed to Infrastructure (pI)
- ✓ Goal of the proposed pricing scheme:
  - ✓ Maximizing profit of SCSP
  - ✓ Maximizing profit of sensor owner
  - ✓ End users' satisfaction

Pricing in Sensor-Cloud



Focus on

- ✓ Maximizing the profit made by SCSP
- ✓ Optimal pricing to the end-users
- ✓ End users satisfaction
- ✓ Pricing attributed to hardware (pH)
  - ✓ Deals with usage of physical sensor nodes
- ✓ Pricing attribute to infrastructure (pI)
  - ✓ Deals with the price associated with infrastructure of sensor-cloud

References

- ✓ Madoka Yuriyama and Takayuki Kushida , “Sensor-Cloud Infrastructure - Physical Sensor Management with Virtualized Sensors on Cloud Computing”, Research Report , IBM Research - Tokyo IBM Japan, Ltd., 2010 (http://domino.research.ibm.com/library/cyberdig.nsf/papers/70E4CC6AD71F2418852577670016F2DE/$File/RT0897.pdf)
- ✓ S. Chatterjee, R. Ladia and S. Misra, "Dynamic Optimal Pricing for Heterogeneous Service-Oriented Architecture of Sensor-Cloud Infrastructure," in IEEE Transactions on Services Computing, vol. 10, no. 2, pp. 203-216, 2017
- ✓ S. Chatterjee and S. Misra, "Optimal composition of a virtual sensor for efficient virtualization within sensor-cloud," 2015 IEEE International Conference on Communications (ICC), London, 2015, pp. 448-453
- ✓ S. Misra; S. Chatterjee; M. S. Obaidat, "On Theoretical Modeling of Sensor Cloud: A Paradigm Shift From Wireless Sensor Network," in IEEE Systems Journal , vol.PP, no.99, pp.1-10

Thank You!!

IIT KHARAGPUR

NPTEL ONLINE CERTIFICATION COURSES

NPTEL

Fog Computing – Part I

Dr. Sudip Misra
Associate Professor
Department of Computer Science and Technology
IIT Kharagpur
Email: smisra@sit.iitkgp.ernet.in
Website: http://cse.iitkgp.ac.in/~smisra/

Introduction

- ✓ Fog computing or fogging is a term coined by CISCO.
- ✓ The idea of fog computing is to extend the cloud nearer to the IoT devices.
- ✓ The primary aim: solve the problems faced by cloud computing during IoT data processing.
- ✓ an intermediate layer between cloud and devices.

Introduction (contd.)

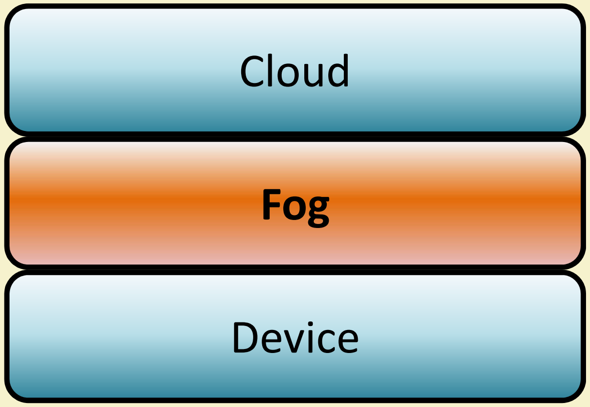


Fig. Fog as intermediate layer between cloud and device

Introduction (contd.)

- ✓ 40% of the whole worlds data will come from sensors alone by 2020.
- ✓ 90% of the world’s data were generated only during the period of last two years.
- ✓ 2.5 quintillion bytes of data is generated per day.
- ✓ total expenditure on IoT devices will be $1.7 Trillion by 2020

Introduction (contd.)

- ✓ the total number of connected vehicles worldwide will be 250 millions by 2020.
- ✓ there will be more than 30 billion IoT devices
- ✓ The amount of data generated by IoT devices is simply huge.

Why Fog Computing

- ✓ The ability of the current cloud model is insufficient to handle the requirements of IoT.
- ✓ Issues are:
  - ✓ Volume
  - ✓ Latency
  - ✓ Bandwidth

Why Fog Computing (contd.)

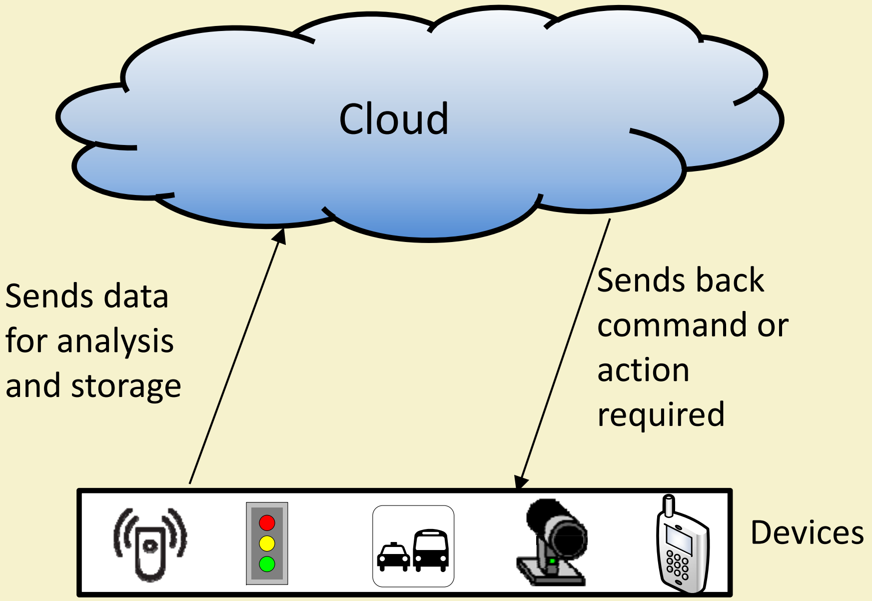


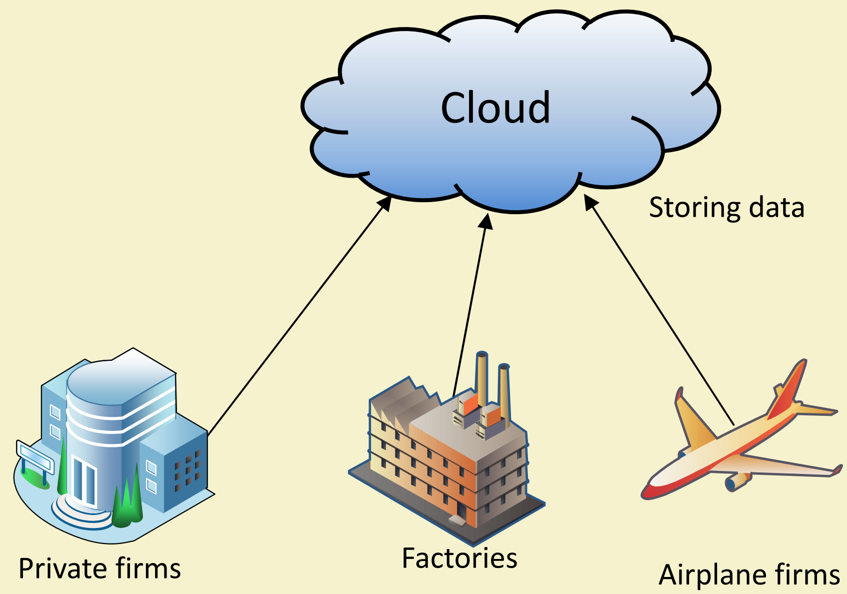
Fig.1: Present day cloud model

Why Fog Computing (contd.)

- ✓ Data Volume:
  - ✓ By 2020, about 50 billion devices will be online.
  - ✓ Presently billions of devices produce exabytes of data everyday.
  - ✓ Device density is still increasing everyday.
  - ✓ Current cloud model is unable to process this amount of data.

Why Fog Computing (contd.)

- ✓ Private firms, Factories, airplane companies produces colossus amount of data everyday
- ✓ Current cloud model cannot store all these data
- ✓ Data need to be filtered



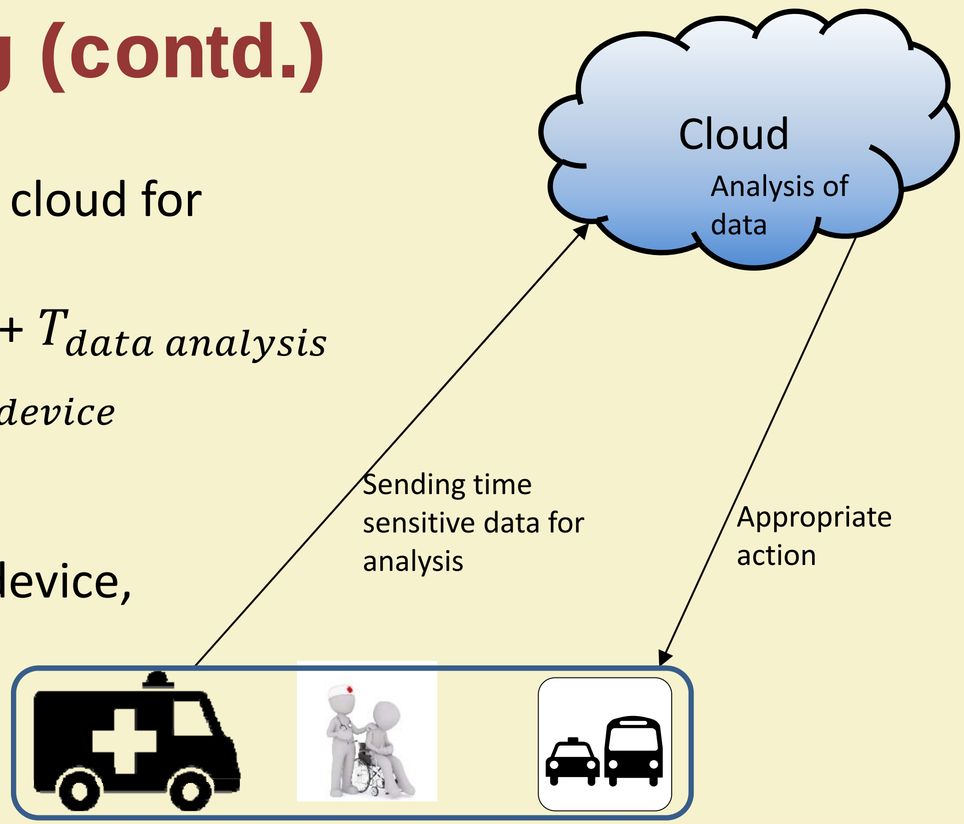
Why Fog Computing (contd.)

- ✓ Latency
  - ✓ Time taken by a data packet for a round trip
  - ✓ An important aspect for handing a time sensitive data.
  - ✓ If edge devices send time sensitive data to cloud for analysis and wait for the cloud to give a proper action, then it can lead to many unwanted results.
  - ✓ While handling time sensitive data, a millisecond can make a huge differences.

Why Fog Computing (contd.)

- ✓ Sending time-sensitive data to cloud for analysis
- ✓ Latency = $T_{from\ device\ to\ cloud} + T_{data\ analysis} + T_{from\ cloud\ to\ device}$

  where T = Time
- ✓ Latency will be increased
- ✓ When the action reaches the device, accident may have already occured

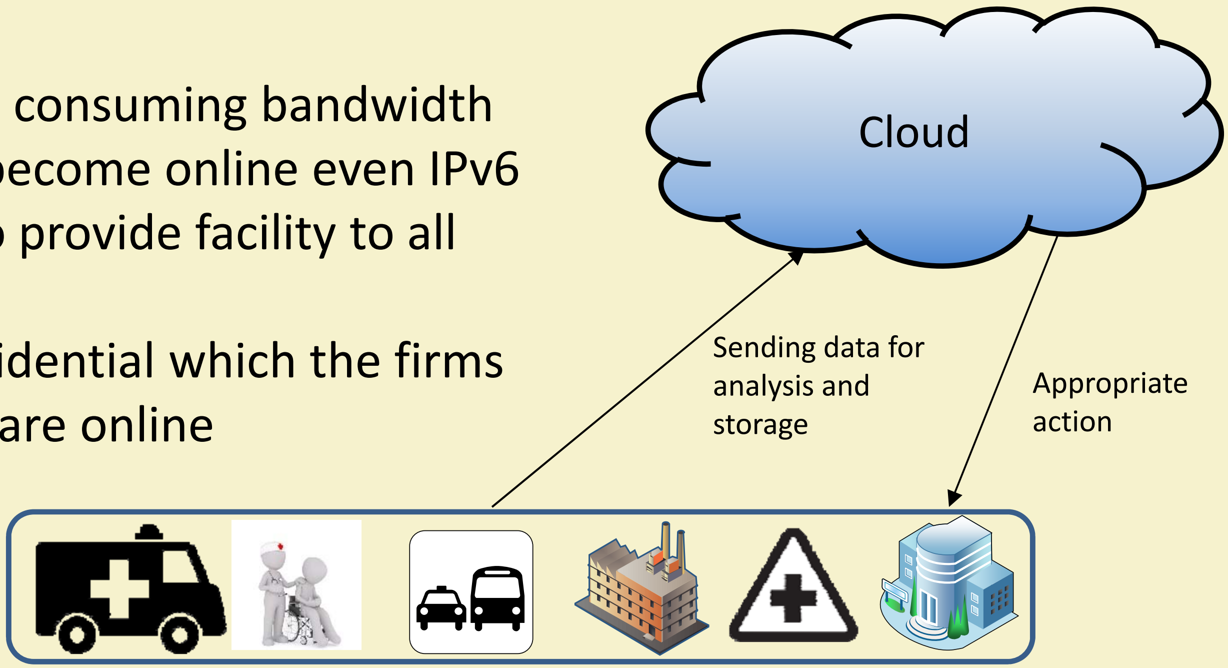


Why Fog Computing (contd.)

- ✓ Bandwidth:
  - ✓ Bit-rate of data during transmission
  - ✓ If all the data generated by IoT devices are sent to cloud for storage and analysis, then, the traffic generated by these devices will be simply gigantic.
  - ✓ consumes almost all the bandwidths.
  - ✓ Handling this kind of traffic will be simply a very hard task.

Why Fog Computing (contd.)

- ✓ Billions of devices consuming bandwidth
- ✓ If all the devices become online even IPv6 will not be able to provide facility to all the devices
- ✓ Data may be confidential which the firms do not want to share online



Requirements of IoT

- ✓ Reduce latency of data:
  - ✓ Appropriate actions at the right time prevents major accidents machine failure etc.
  - ✓ A minute delay while taking a decision makes a huge difference
  - ✓ Latency can be reduced by analyzing the data close to the data source

Requirements of IoT (contd.)

- ✓ Data security:
  - ✓ IoT data must be secured and protected from the intruders.
  - ✓ Data are required to be monitored 24x7
  - ✓ An appropriate action should be taken before the attack causes major harm to the network

Requirements of IoT (contd.)

- ✓ Operation reliability:
  - ✓ The data generated from IoT devices are used to solve real time problem
  - ✓ Integrity and availability of the data must be guaranteed
  - ✓ Unavailability and tampering of data can be hazardous

Requirements of IoT (contd.)

- ✓ Processing of data at respective suitable place:
  - ✓ Data can be divided into three types based on sensitivity
    - ✓ time sensitive data
    - ✓ less time sensitive data
    - ✓ data which are not time sensitive
  - ✓ Extremely time sensitive data should be analyzed very near to the data source
  - ✓ Data which are not time sensitive will be analyzed in the cloud.

Requirements of IoT (contd.)

- ✓ Monitor data across large geographical area:
  - ✓ The location of connected IoT devices can be spread across a large geographical region
  - ✓ E.g. monitoring the railway track of a country or a state
  - ✓ the devices are exposed to the harsh environments condition

When should we use fog

- ✓ If the data should ne analyze with fraction of second
- ✓ If there are huge number of devices
- ✓ If the devices are separated by a large geographical distance
- ✓ If the devices are needed to be subjected to extreme conditions

Thank You!!

IIT KHARAGPUR

NPTEL ONLINE CERTIFICATION COURSES

NPTEL

Fog Computing – Part II

Dr. Sudip Misra

Associate Professor

Department of Computer Science and Technology

IIT Kharagpur

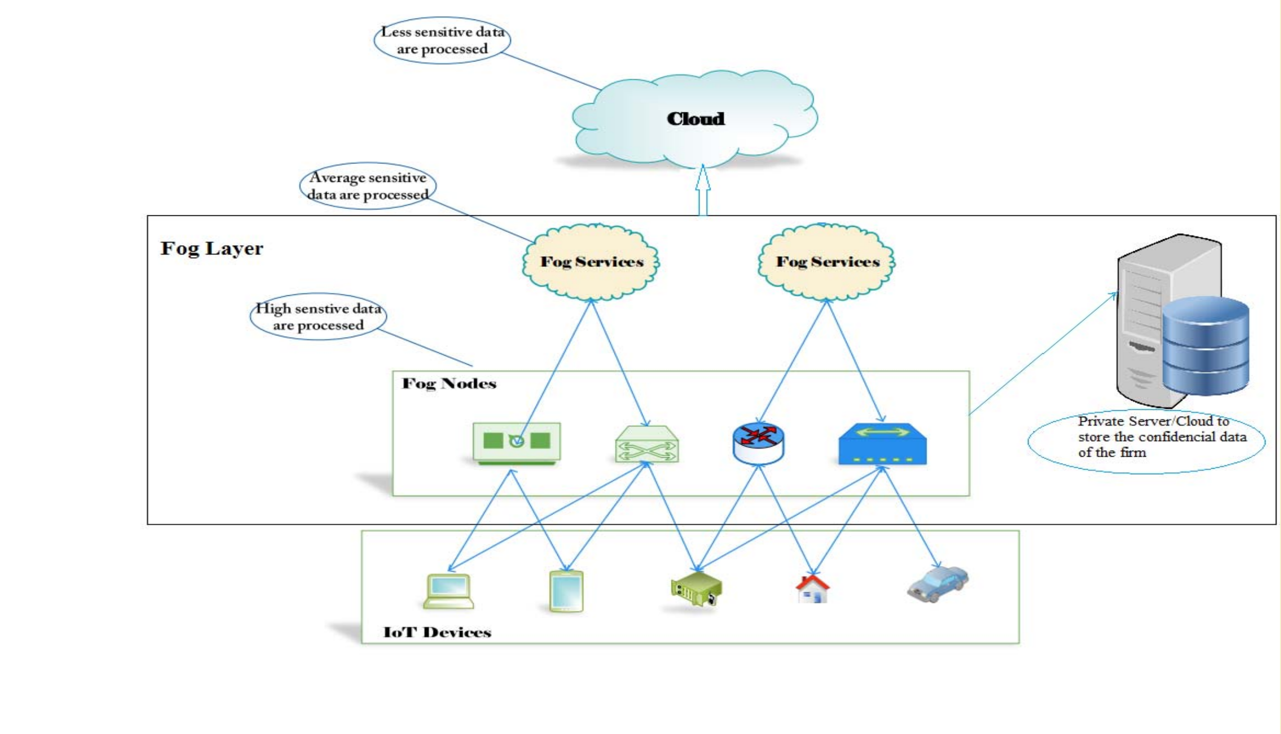
Email: smisra@sit.iitkgp.ernet.in

Website: http://cse.iitkgp.ac.in/~smisra/

Architecture of Fog

- ✓ Cloud services are extended to IoT devices through fog
- ✓ Fog is a layer between cloud and IoT devices
- ✓ many fog nodes can be present
- ✓ Sensor data are processed in the fog before it is sent to the cloud
- ✓ Reduces latency, save bandwidth and save the storage of the cloud

Architecture of Fog (contd.)



Fog nodes

- ✓ Characteristics for a fog node:
  - ✓ Storage - To give transient storage
  - ✓ Computing facility
    - To process the data before it is sent to cloud
    - To take quick decisions
  - ✓ Network connectivity - To connect with IoT devices, other fog nodes and cloud

Fog nodes (contd.)

- ✓ E.g. - routers, embedded servers, switches, video surveillance cameras, etc.
- ✓ deployable anywhere inside the network.
- ✓ Each fog nodes have their aggregate fog node.

Working of Fog

- ✓ Three types of data
  - ✓ Very time-sensitive data
  - ✓ Less time-sensitive data
  - ✓ Data which are not time-sensitive
- ✓ Fog nodes works according to the type of data they receive.
- ✓ An IoT application should be installed to each fog nodes

Working of Fog (contd.)

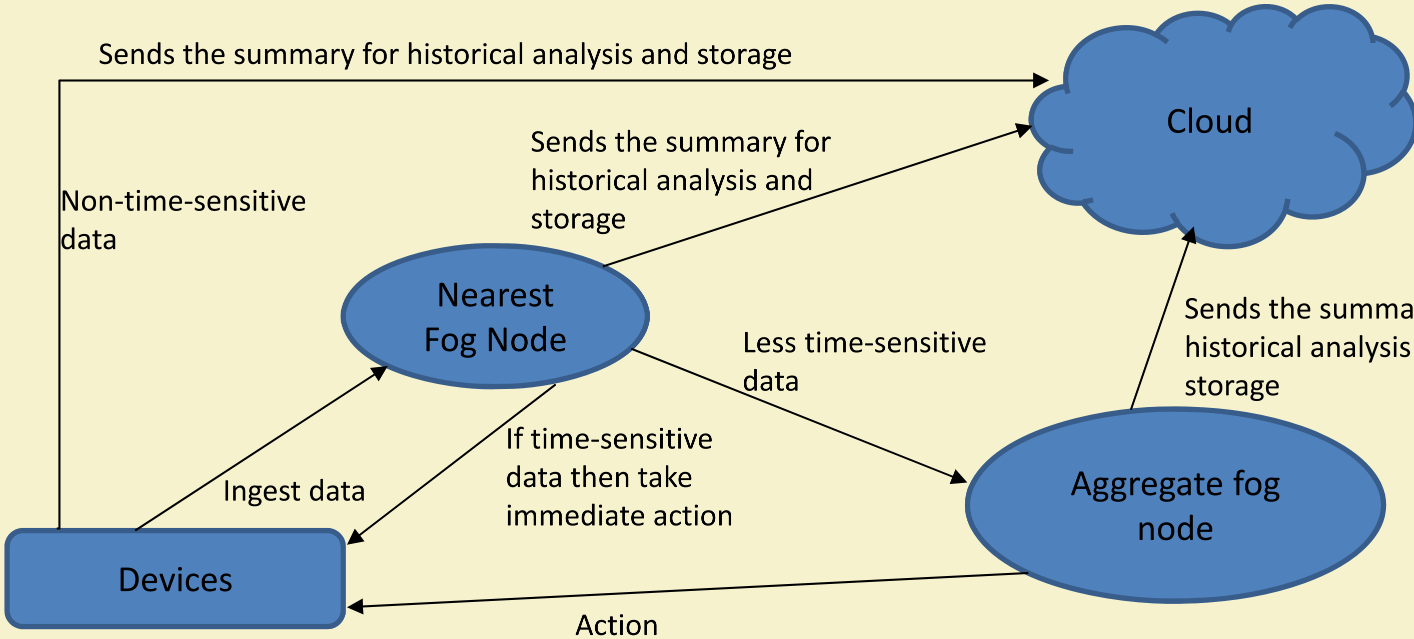


Fig : Working of fog

Working of Fog (contd.)

- ✓ The nearest fog node ingest the data from the devices.
- ✓ Most time-sensitive data
  - ✓ Data which should be analyzed within fraction of a second
  - ✓ Analyze at the nearest node itself
  - ✓ Sends the decision or action to the devices
  - ✓ Sends and stores the summary to cloud for future analysis

Working of Fog (contd.)

- ✓ Less time-sensitive data
  - ✓ Data which can be analyzed after seconds or minutes
  - ✓ Are sent to the aggregate node for analysis
  - ✓ After analysis, the aggregate node send the decision or action to the device through the nearest node
  - ✓ The aggregate node sends the summary to cloud for storage and future analysis.

Working of Fog (contd.)

- ✓ Non-time-sensitive data
  - ✓ Data which can be wait for hours, days, weeks
  - ✓ Sent to cloud for storage and future analysis.
  - ✓ Those summaries from fog nodes can be considered as less time sensitive data.

Working of Fog (contd.)

	Fog node closest to devices	Fog aggregate nodes	Cloud
Analysis duration	Fraction of second	Seconds to minutes	Hours to weeks
IoT data storage duration	Transient	Hour, days	Months to years
Geographical coverage	Very local	Wider	Global

Advantages of Fog

- ✓ Security
  - ✓ Provides better security
  - ✓ Fog nodes can use the same security policy
- ✓ Low operation cost
  - ✓ Data are processed in the fog nodes before sending to cloud
  - ✓ Reduces the bandwidth consumption

Advantages of Fog (contd.)

- ✓ Reduces unwanted accidents
  - ✓ Latency will be reduce during decision making
  - ✓ Quick decision making
- ✓ Better privacy
  - ✓ Every industry can analyze their data locally
  - ✓ Store confidential data in their local servers
  - ✓ Send only those data which can be shared to the cloud

Advantages of Fog (contd.)

- ✓ Business agility
  - ✓ Fog application can be easily developed according to tools available
  - ✓ Can be deployed anywhere we need
  - ✓ Can be programed according to the customer’s need
- ✓ Support mobility
  - ✓ Nodes can be mobile
  - ✓ Nodes can join and leave the network anytime

Advantages of Fog (contd.)

- ✓ Deployable in remote places
  - ✓ Can be deployed in remote places
  - ✓ Can be subjected to harsh environmental conditions
  - ✓ Under sea, railway tracks, vehicles, factory floor etc
- ✓ Better data handling
  - ✓ Can operate with less bandwidth
  - ✓ Data can be analyzed locally
  - ✓ Reduce the risk of latency

Applications of Fog

- ✓ Real time health analysis
  - ✓ Patients with chronic illness can be monitored in real time
  - ✓ Stroke patients
  - ✓ Analyze the data real time
  - ✓ During emergency, alerts the respective doctors immediately
  - ✓ Historical data analysis can predict future dangers of the patient

Applications of Fog (contd.)

- ✓ Intelligence power efficient system
  - ✓ Power efficient
  - ✓ Reports detail power consumption report everyday
  - ✓ Suggest economical power usage plan

Applications of Fog (contd.)

- ✓ Real time rail monitoring
  - ✓ Fog nodes can be deployed to railway tracks
  - ✓ Real time monitoring of the track conditions
  - ✓ For high speed train, sending the data in cloud for analysis is inefficient
  - ✓ Fog nodes provide fast data analysis
  - ✓ Improve safety and reliability

Applications of Fog (contd.)

- ✓ Pipeline optimization
  - ✓ Gas and oils are transported through pipelines
  - ✓ Real time monitoring of pressure, flow, compressor is necessary
  - ✓ Terabytes of data are created
  - ✓ Sending all this data to cloud for analysis and storage is not efficient
  - ✓ Network latency is not acceptable
  - ✓ Fog is a solution

Applications of Fog (contd.)

- ✓ Real time wind mill and turbine analysis
  - ✓ Wind direction and speed analysis can increase output
  - ✓ Data can be monitored real time

Challenges

- ✓ Power consumption
  - ✓ Fog use addition nodes
  - ✓ Power consumption is higher than centralized cloud
- ✓ Data Security
  - ✓ Data generating nodes are distributed
  - ✓ Providing authentication and authorization system for the whole nodes is not an easy task
- ✓ Reliability
  - ✓ Maintaining data integrity and availability for millions of nodes is difficult
  - ✓ failure of a node cannot affect the network

Challenges (contd.)

- ✓ Fault tolerance
  - ✓ Failure of a node should be immediately fixed
  - ✓ Individual failure should not affect the whole scenario
- ✓ Real time analysis
  - ✓ Real time analysis is a primary requirement for minimizing latency
  - ✓ Dynamic analysis and decision making reduces danger and increase output
  - ✓ Monitor huge number of nodes is not easy

Challenges (contd.)

- ✓ Programming architecture
  - ✓ Fog nodes may be mobile
  - ✓ Nodes can connect and leave the network when necessary
  - ✓ Many data processing frameworks are statically configured
  - ✓ These frameworks cannot provide proper scalability and flexibility

Conclusion

- ✓ Fog is a perfect partner for cloud and IoT
- ✓ Solves the primary problems faced by cloud while handling IoT data
- ✓ Benefits extends from an individual person to huge firms
- ✓ Provides real time analysis and monitoring

References

- ✓ Amir Vahid Dastjerdi, Rajkumar Buyya, Fog Computing: Helping the Internet of Things realize its potential, IEEE Fog computing, August 2016
- ✓ CISCO white paper, Fog Computing and the Internet of Things: Extend the Cloud to Where the Things Are, 2015
- ✓ R System white paper, Fog Computing for Big Data analytics, October 2016
- ✓ Redowan Mahmud,Rajkumar Buyya, Fog Computing: A Taxonomy, Survey and future Directions,Cornell University Library, November 2016
- ✓ http://www.businessinsider.in/THE-INTERNET-OF-EVERYTHING-2015-SLIDE-DECK/articleshow/45695215.cms
- ✓ http://www.gartner.com/newsroom/id/2970017
- ✓ https://www.uschamberfoundation.org/bhq/big-data-and-what-it-means
- ✓ https://www.afcea.org/content/?q=node/12239

Thank You!!