ARCHITECTURAL EXAMPLES

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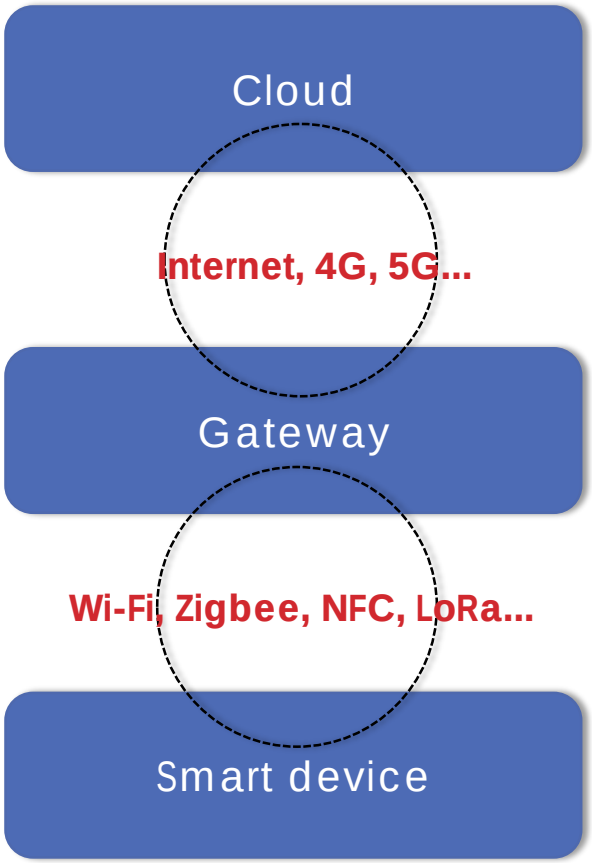
Reminder – High level architecture

This layer provides inside to the data collected from all layers. It provides the information as a service to individuals, industries or infrastructures.

This layer runs local, real-time services and enables the stream of data to move from one level to the next for more processing.

This layer enables interface to objects that are currently passive, tapping into these objects generates a stream of pertinent data.



Purpose of this lecture

See how this generic architecture is being applied across different domains

Show the architectural qualities in these different cases

Agenda

Architectural qualities

Architectural variants

- No cloud
- No fog
- Basic gateway
- Smart gateway
- Collaborative gateways
- Remote gateways

Challenges and conclusion

Software qualities

The primary quality of a software system is to do what is expected

meet its requirements and be in conformance with its specifications

It also has structural qualities related to the way it is built

It can be robust, extensible, available, etc.

These qualities depend very much on the architecture

Quality attributes

Quality attributes are also called non functional requirements.

They can be divided into two main categories

execution quality are observable at runtime

security, usability, etc..

evolution quality are embodied in the structure of the system and are visible when evolutions are needed

testability, scalability, etc.

(another classification: internal vs external qualities)

List of quality attributes (wikipedia)

- Accessibility
- Audit and control
- Availability (see service level agreement)
- Backup
- Capacity, current and forecast
- Certification
- Compliance
- Configuration management
- Dependency on other parties
- Deployment
- Documentation
- Disaster recovery
- Efficiency (resource consumption for given load)
- Effectiveness (resulting performance in relation to effort)
- Emotional factors (like fun or absorbing or has "Wow! Factor")
- Environmental protection
- Escrow
- Exploitability
- Extensibility (adding features, and carry-forward of customizations at next major version upgrade)
- Failure management
- Fault tolerance (e.g. Operational System Monitoring, Measuring, and Management)
- Legal and licensing issues or patent-infringement-avoidability
- Interoperability
- Maintainability
- Modifiability
- Network topology
- Open source
- Operability
- Performance / response time (performance engineering)
- Platform compatibility
- Price
- Privacy
- Portability
- Quality (e.g. faults discovered, faults delivered, fault removal efficacy)
- Readability
- Recovery / recoverability (e.g. mean time to recovery - MTTR)
- Reliability (e.g. mean time between failures - MTBF, or availability)
- Reporting
- Resilience
- Resource constraints (processor speed, memory, disk space, network bandwidth, etc.)
- Response time
- Reusability
- Robustness
- Safety or Factor of safety
- Scalability (horizontal, vertical)
- Security
- Software, tools, standards etc. Compatibility
- Stability
- Supportability
- Testability
- Throughput
- Transparency
- Usability by target user community

Quality model

A quality model defines a set of quality attributes (and metrics) for system evaluation

implies classification and terminology

many different models have been defined (ISO 9126)

no consensus

often domain-dependent

CISQ: 5 qualities to provide business value

Reliability

Resiliency and structural solidity – likelihood of failures during execution or after a change

Efficiency

Ensure high performance, avoid response-time degradation and ensure optimal usage of resources

Security

Likelihood of potential security breaches , including loss of privacy

Maintainability

Ability to extend the software to meet business-driven changes and to be scalable to get new customers. Costs must be kept under control.

Code

Size and complexity of code obviously impact software quality (related to modularity, coupling and cohesion).

Quality table (to be filled in)

Quality attribute	Assessment
Reliability (resiliency/solidity)	
Efficiency (performance/res. usage)	
Security (breaches/privacy)	
Maintainability (extensibility/scalability)	
Code (size/complexity)	

Agenda

Architectural qualities

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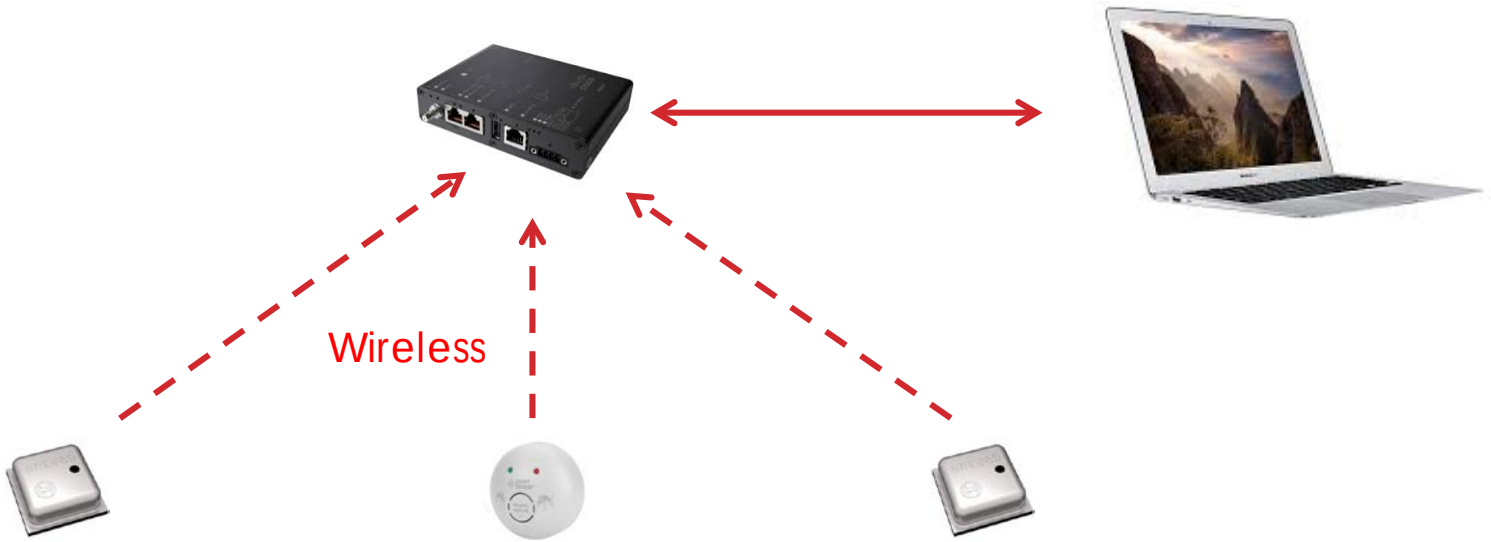
Challenges and conclusion

“No Cloud” architecture

The architecture is limited to sensors and gateways

- Wireless connection
- Services provided by the sensors (if smart enough) and the gateway
- PC-based HMI (Internet or Wi-Fi)

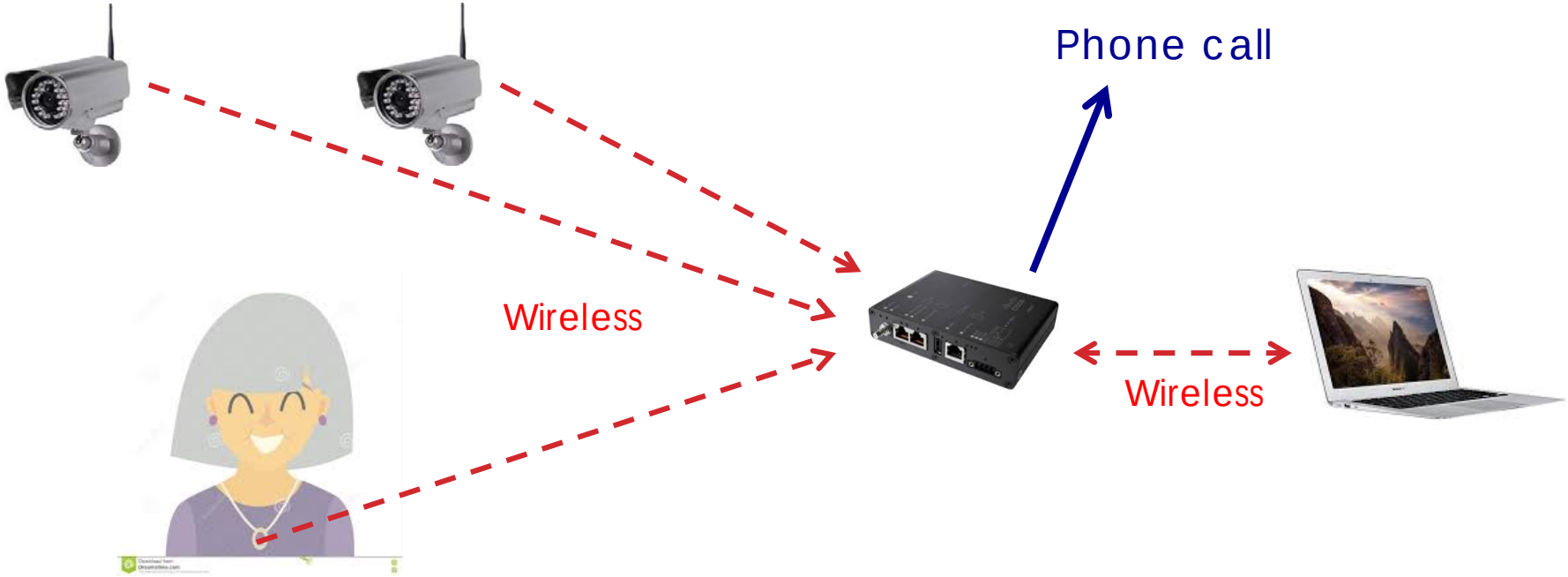


Example

Fall detection

Fall is detected locally by wearable devices or cameras

The gateway is connected to a call center



Assessment

Quality attribute	Assessment
Reliability (resiliency/solidity)	Good Weak point is the connection devices/gateway Side effects should be limited
Efficiency (performance/res. usage)	Very good. Fully decentralized.
Security (breaches/privacy)	Wireless communication can be hacked Devices can be hacked
Maintainability (extensibility/scalability)	Functional extensions are very limited Devices can be added/replaced New customers (houses) can be added
Code (size/complexity)	Relatively simple: code on a single platform. Size is also manageable.

Domains of applicability

Reactive systems with no historical data (for learning...)

Control in the plant floor

Surveillance in a building, a house, ...

Pre-IoT era!

Agenda

Architectural qualities

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Challenges and conclusion

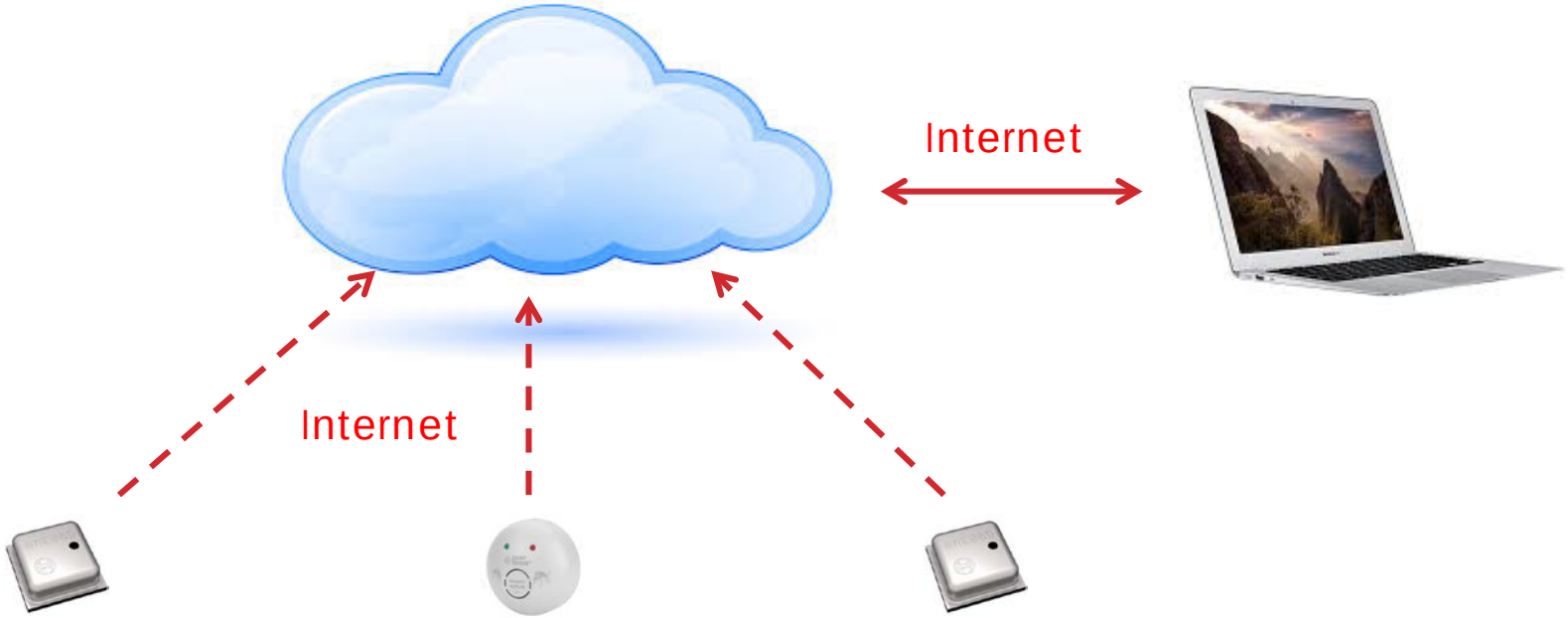
“No Fog” architecture

The architecture consists of sensors and cloud computers

Internet connection

Services provided by the sensors and by cloud computers

Web-based HMI



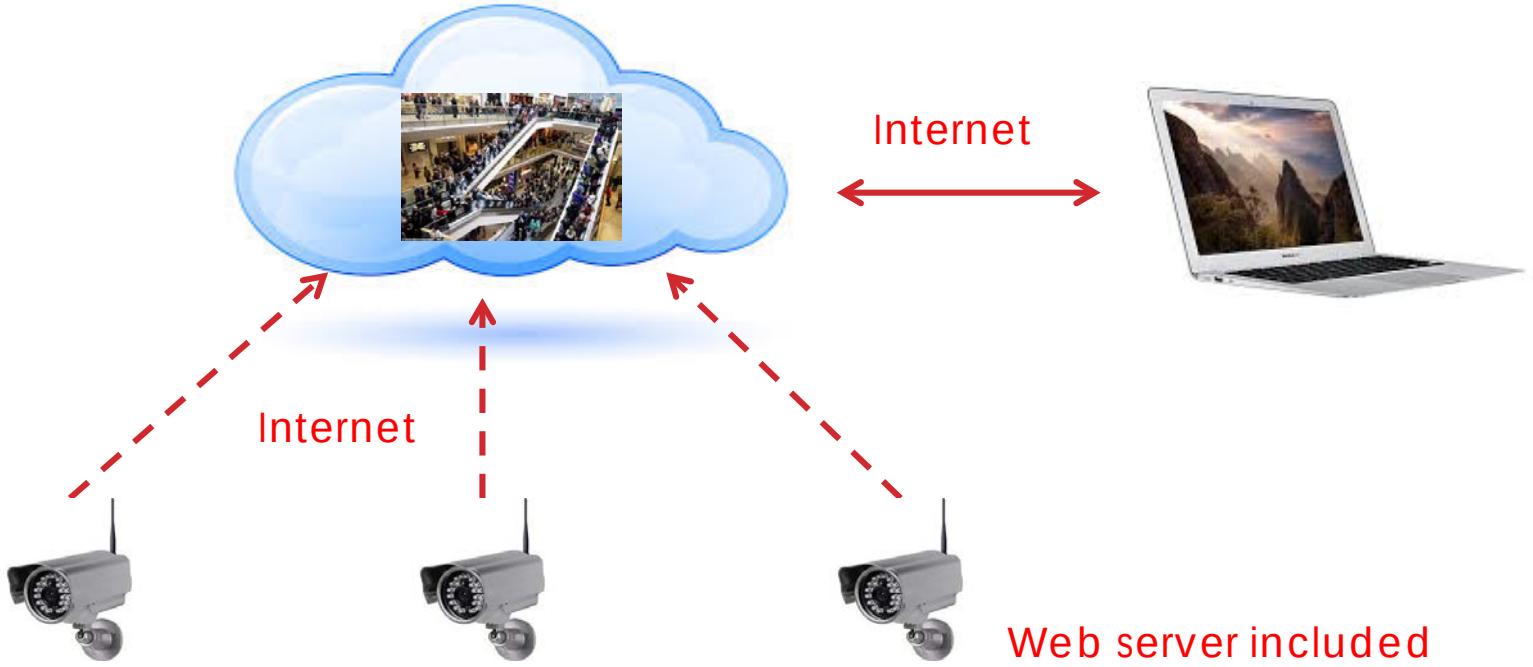
Example

(Web) Camera based surveillance (of a crowd in a mall)

Cloud computers store and process

Situation analysis and alarm triggering if fire detected

Results are presented to an analyst (and alarms are sent)



Assessment

Quality attribute	Assessment
Reliability (resiliency/solidity)	Poor If Internet connection is lost, no backup solution
Efficiency (performance/res. usage)	Poor Nominal performance can be fine but: - Internet connection can be lost - Transmitted data volume is unmanaged
Security (breaches/privacy)	Internet communication can be hacked Devices can be hacked
Maintainability (extensibility/scalability)	Very limited functional extensions (cloud) Devices can be added/replaced Poor scalability regarding cameras
Code (size/complexity)	Size is manageable Can be complex at the cloud level Advanced platform needed to add services

Domains of applicability

Long-term analysis

Big data

learning

Not much data or light data

Agenda

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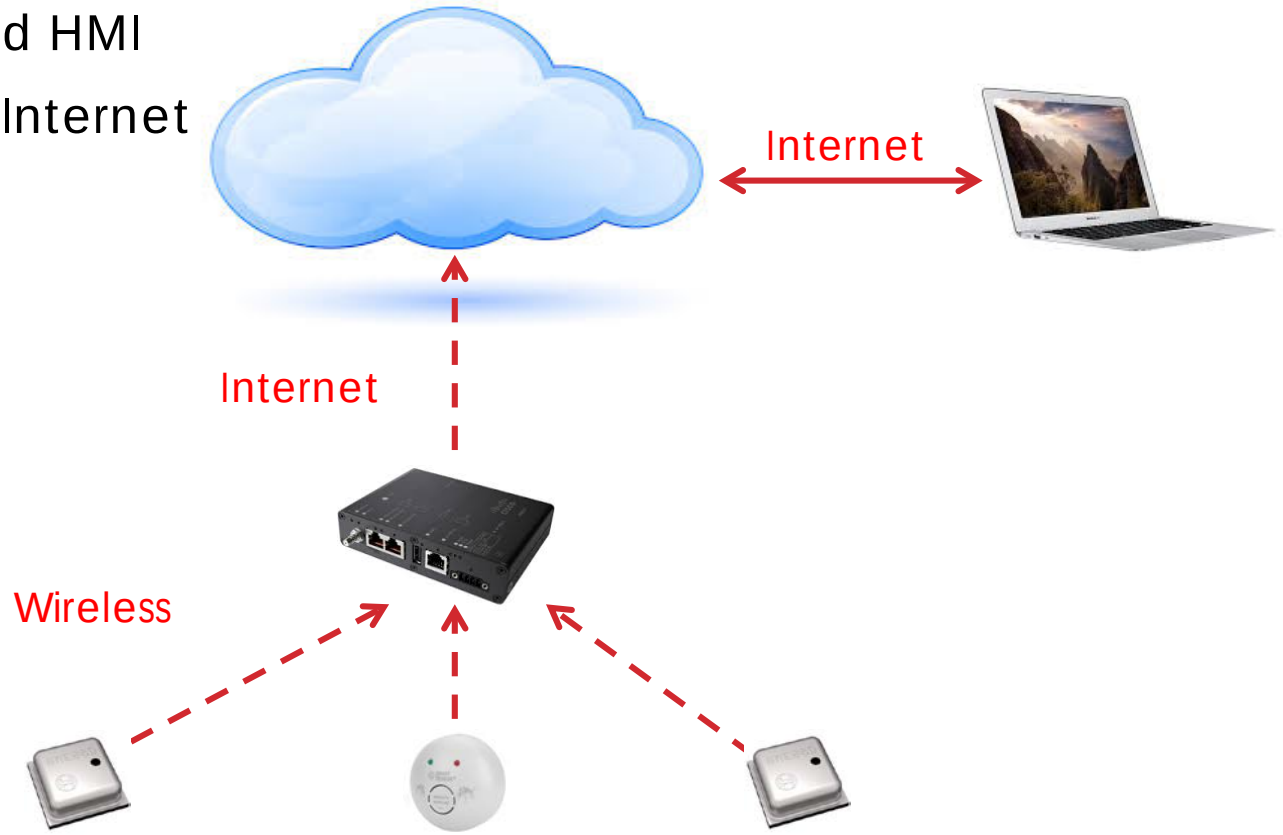
Challenges and conclusion

“Smart gateway” architecture

Three-layer architecture (sensors, gateway, cloud)

- Services provided by the cloud computers
- Gateway prunes, aggregate and send up data
- Web-based HMI
- Wireless & Internet



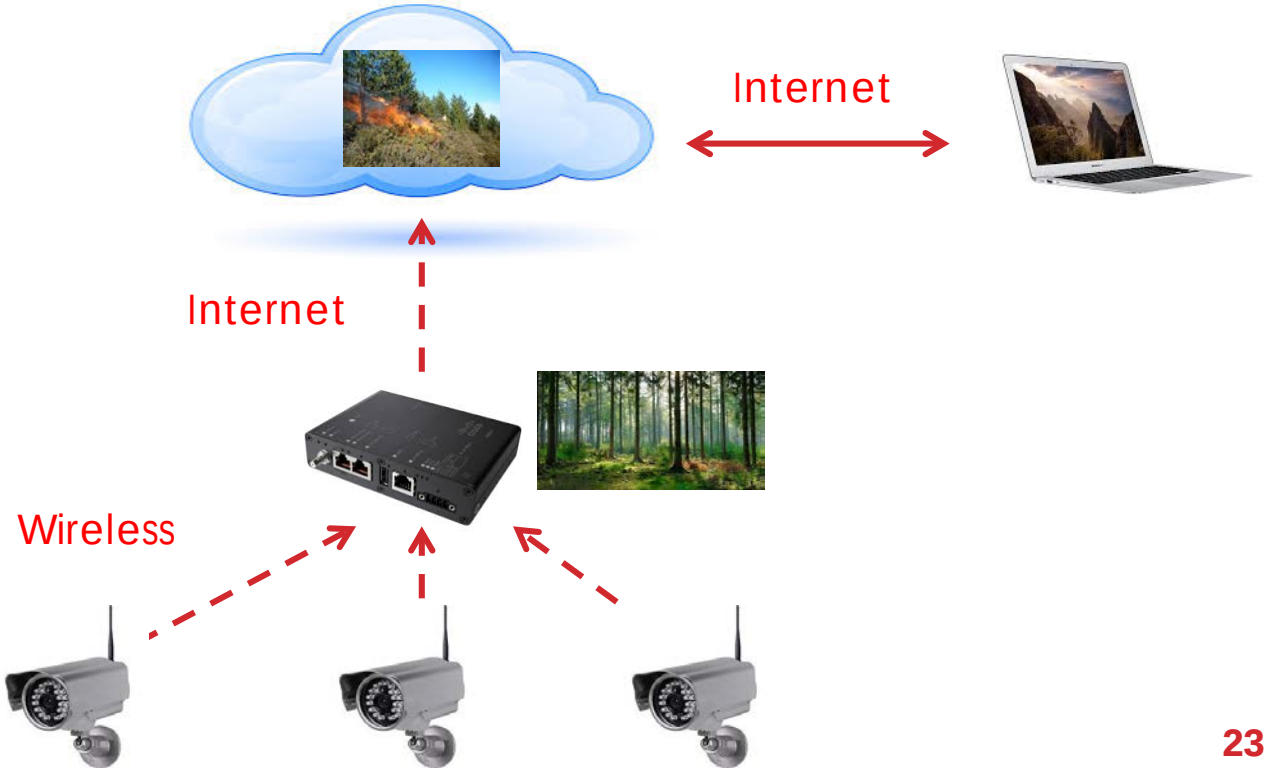
Example

Camera based fire surveillance

Cloud computers store and process (do situation analysis)

Gateways store a few image, send if suspicions

Results are presented to an analyst (and alarms are sent)



Assessment

Quality attribute	Assessment
Reliability (resiliency/solidity)	Medium If Internet connection is lost, images can be stored at the gateway level
Efficiency (performance/res. usage)	Medium Transmitted data volume is managed Degradation If Internet connection is lost
Security (breaches/privacy)	Internet communication can be hacked Wireless connections can be hacked Devices can be hacked
Maintainability (extensibility/scalability)	Limited functional extensions (cloud) The number of devices is scalable –gateways can be added if needed.
Code (size/complexity)	Size is manageable Modularization is ok. Advanced platform needed to add services

Domains of applicability

Long-term analysis

Big data

learning

Many data in the ground (or heavy data)

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Challenges and conclusion

“Smart gateway” architecture

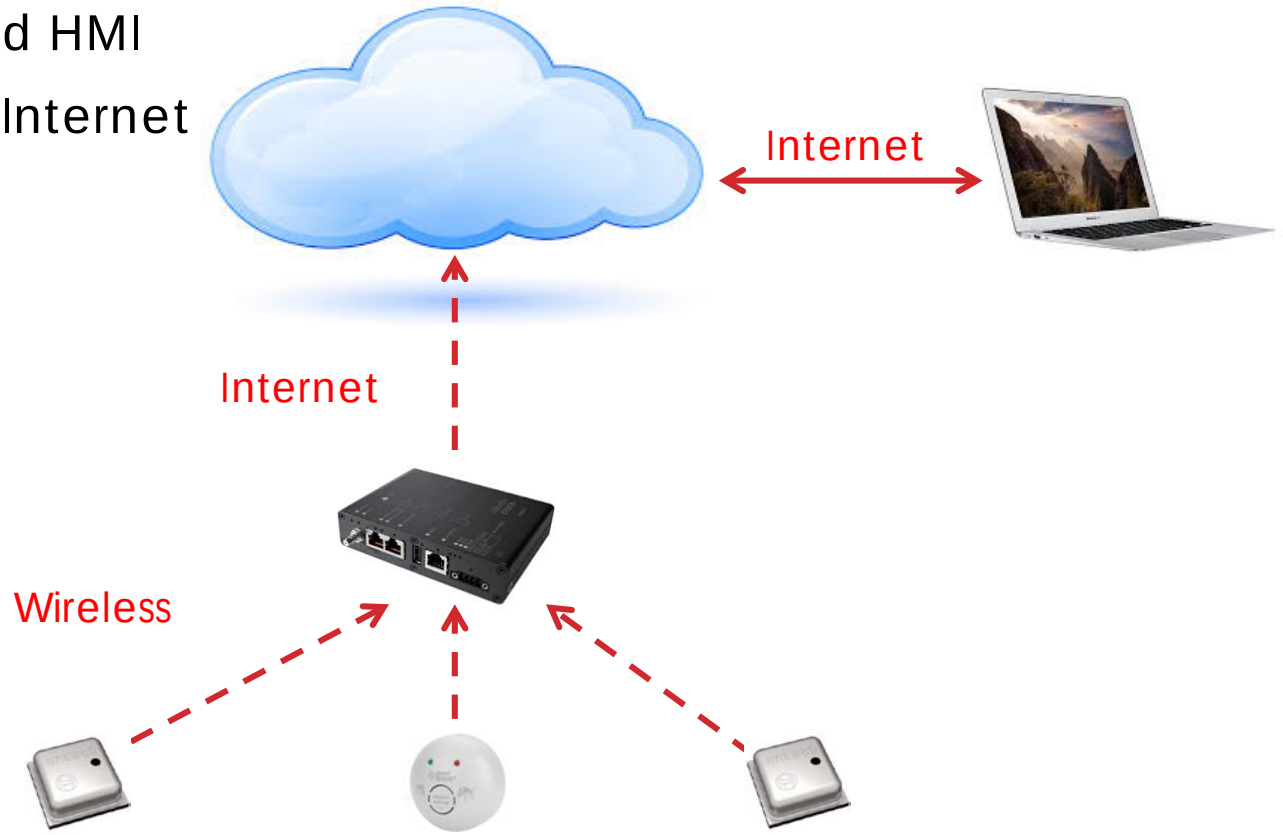
Three-layer architecture (sensors, gateway, cloud)

Services provided by the cloud computers and the gateway

Gateway provide services and send up data

Web-based HMI

Wireless & Internet

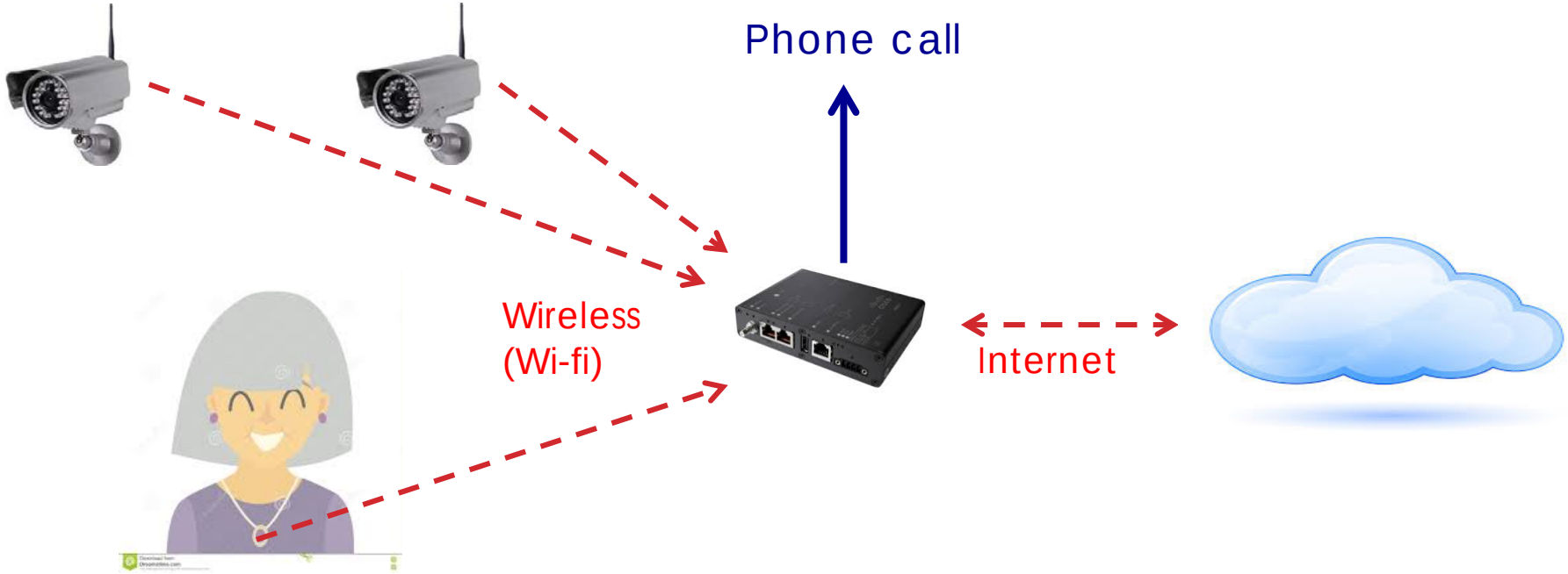


Example

Advanced fall detection

Fall is detected locally by wearable devices or cameras

Cloud services perform long-term analyses (send to doctors)



Assessment

Quality attribute	Assessment
Reliability (resiliency/solidity)	Good Gateway deals with real-time processing and cloud with longer term calculus. If connection is lost, there is no short term impact
Efficiency (performance/res. usage)	Good Transmission of transformed data No degradation If Internet connection is lost
Security (breaches/privacy)	Internet communication can be hacked Wireless connections can be hacked Devices can be hacked
Maintainability (extensibility/scalability)	Functional extensions can be done in the cloud The number of devices is scalable –gateways can be added if needed
Code (size/complexity)	Medium code complexity Good modularization Advanced platforms needed to add services

Domains of applicability

Mix of reactive actions and long-term analysis

- Need to react fast (control)
- Big data and learning opportunities

Agenda

Architectural qualities

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Challenges and conclusion

“Smart multi-apps gateway” architecture

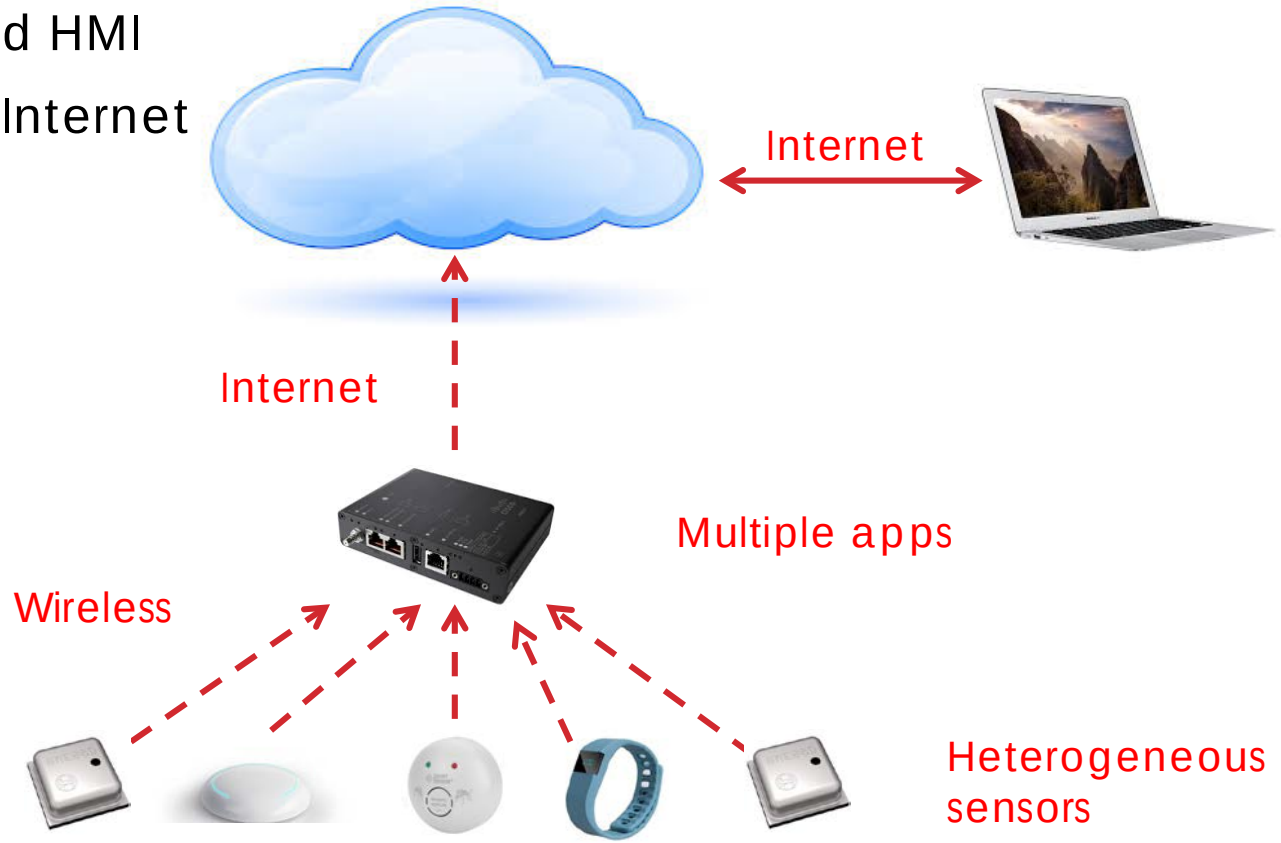
Three-layer architecture (sensors, gateway, cloud)

Apps are distributed between gateway and cloud

Gateway provide various services and send up data

Web-based HMI

Wireless & Internet



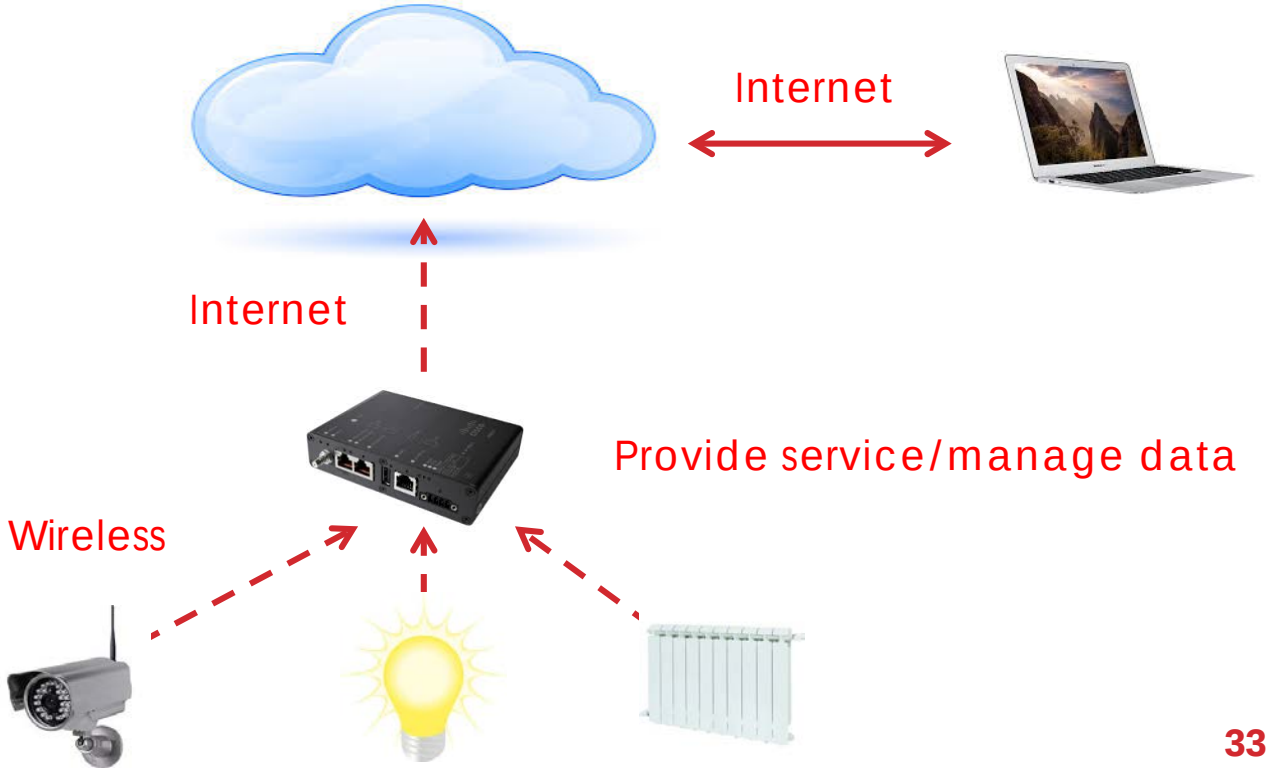
Example

Home automation

Energy management, light management, actimetrics, etc.

Reactive apps at the gateway layer – more advanced services at the cloud level

Gateways store data, aggregate and send up



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Efficiency (performance/res. usage)	Good Transmission of transformed data No degradation If Internet connection is lost
Security (breaches/privacy)	Internet communication can be hacked Wireless connections can be hacked Devices can be hacked
Maintainability (extensibility/scalability)	Functional extensions can be done in the cloud The number of devices is scalable –gateways can be added if needed
Code (size/complexity)	Code can be complex Updates can be complex Advanced platforms needed to add services

Domains of applicability

Coherent and multiple applications in a domain

Need to share data

Need to manage conflicts

Need to bring coherency

Research still going on

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Challenges and conclusion

“Collaborative gateway” architecture

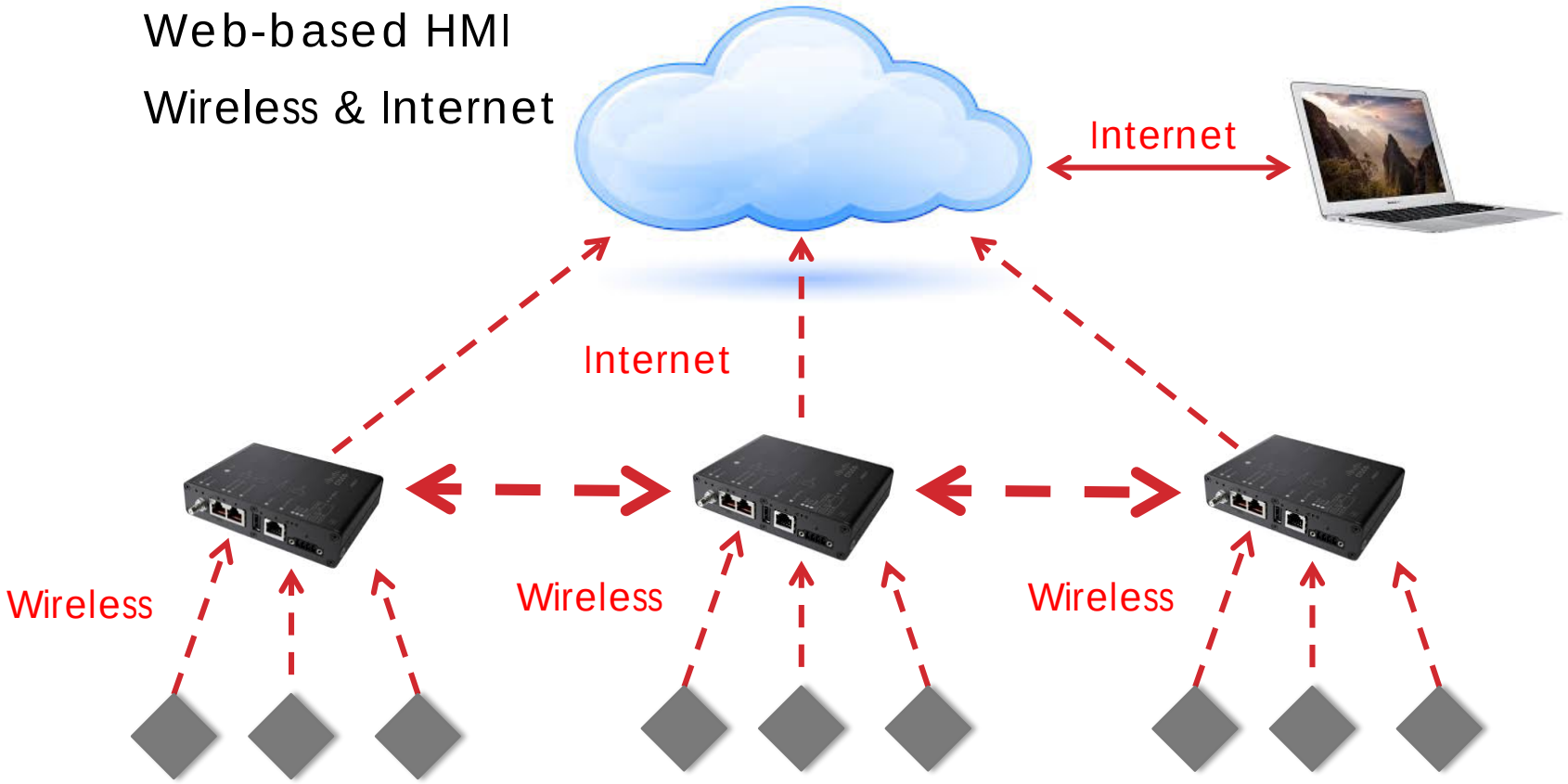
Three-layer architecture (sensors, gateway, cloud)

Services provided by the cloud computers and the gateway

Gateway collaborate to provide services

Web-based HMI

Wireless & Internet



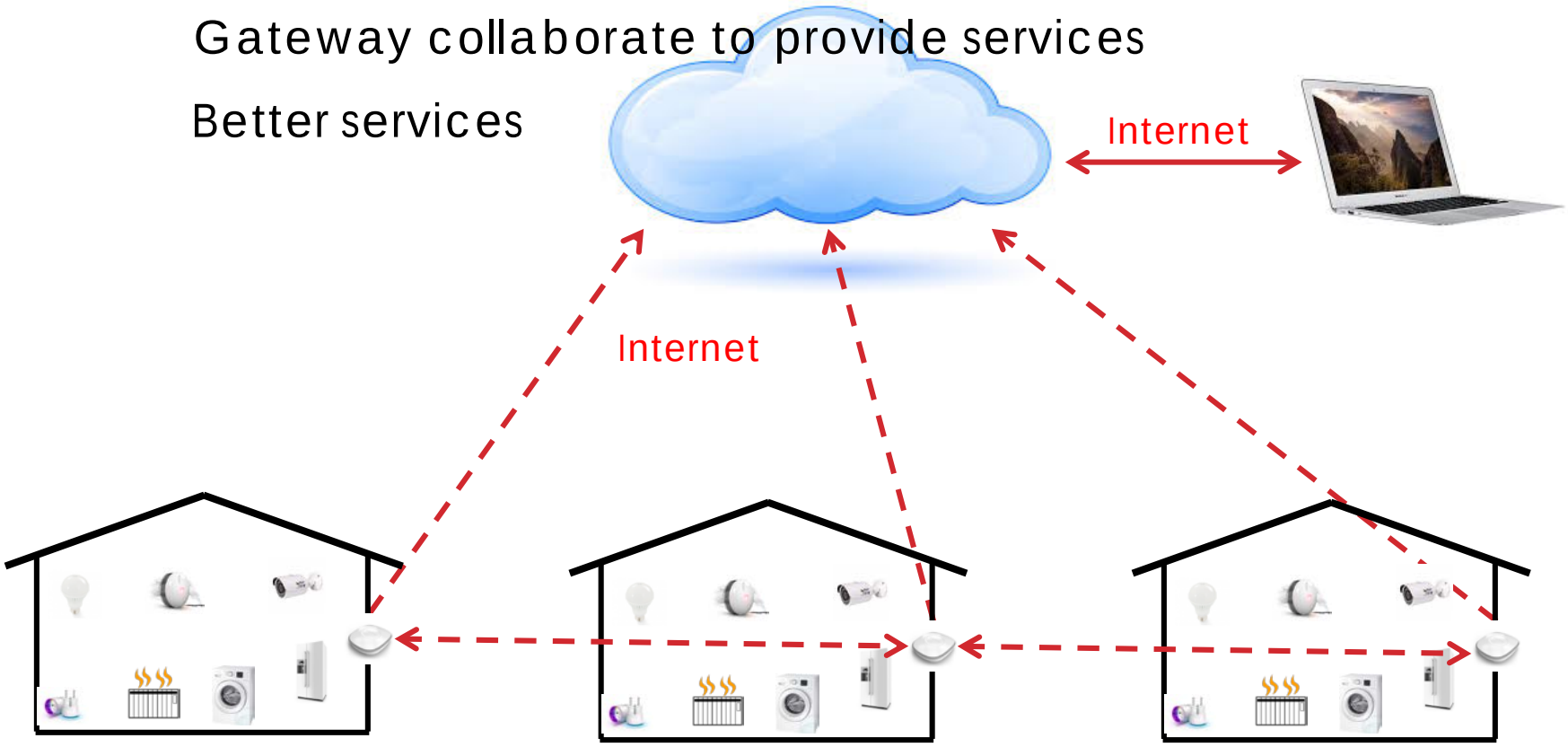
Example

Smart homes in collaboration for better energy mngt

Services provided by the cloud computers and the gateway

Gateway collaborate to provide services

Better services



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Efficiency (performance/res. usage)	Good Transmission of transformed data No degradation If Internet connection is lost
Security (breaches/privacy)	Internet communication can be hacked Wireless connections can be hacked Devices can be hacked
Maintainability (extensibility/scalability)	Functional extensions can be done in the cloud The number of devices is scalable –gateways can be added if needed
Code (size/complexity)	Code management can be very complex Advanced platforms needed to add services

Domains of applicability

Advanced services

Need to get information from remote sensors

Big data and learning opportunities

Big research needs

Agenda

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Challenges and conclusion

Conclusion

The big challenge is to find the best architecture for a given application

Understand the qualities

- a matter of compromise
- no way to catch them ‘all!

Future

Towards a global architecture where applications can be downloaded/configured/moved