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An Access Control Framework for Cloud-Enabled Wearable Internet of Things

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Introduction

- Internet of Things (IoT)
  - Interconnection of Internet-enabled smart devices/things
  - Enabling technologies – *Internet, Cloud and Mobile computing, Big Data and Analytics, M2M technologies and communication protocols, …*
  - Diverse and pervasive concept
  - Numerous IoT applications and services → various subfields of IoT
- Wearable Internet of Things (WIoT)
  - Revolutionizing industries like healthcare, and sports and fitness
  - Enabling technologies – *Internet, Smart phones, WSNs, and WBANs*
- Generally, IoT devices are resource constraint by nature
  - Limited storage, power, and computation

Introduction (Contd.)

- Cloud-Enabled Internet of Things (CEIoT)
  - Integration of Cloud and IoT
  - Major cloud services providers (e.g., AWS, Azure) utilize their cloud infrastructure to provide IoT solutions
  - Virtually unlimited resources with analysis and visualization capabilities
- Security and privacy are primary concerns for IoT
- Here, we present an Access Control (AC) framework for CEIoT in context of WIoT (i.e. CEWIoT)

Background

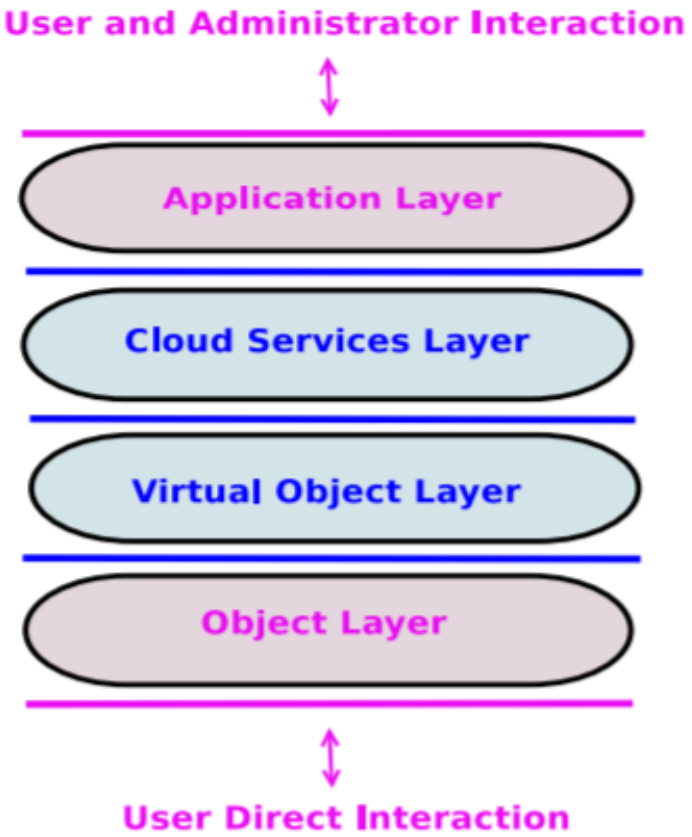


Fig 1: An Access Control Oriented (ACO) Architecture for the CEIoT [1]

Contributions

- Present a general classification of IoT devices to realize different sub-fields of IoT
- Enhance the ACO architecture for CEWIoT by adding an **Object Abstraction Layer**
- Develop an Access Control (AC) framework for CEWIoT based on our enhanced ACO architecture
- Develop a use case to capture different interactions between ACO layers and propose its possible enforcement in a commercial CEIoT platform, viz., AWS IoT

Classification of IoT Devices

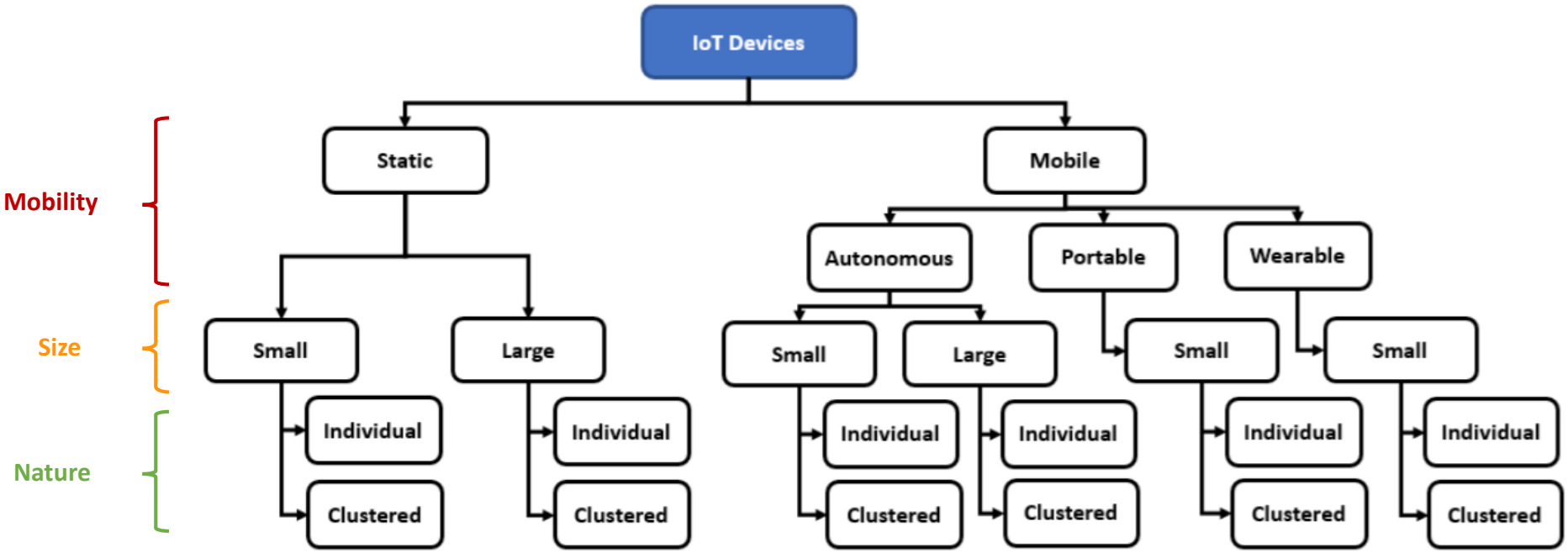


Fig 2: A General Classification of IoT Devices

IoT Domains

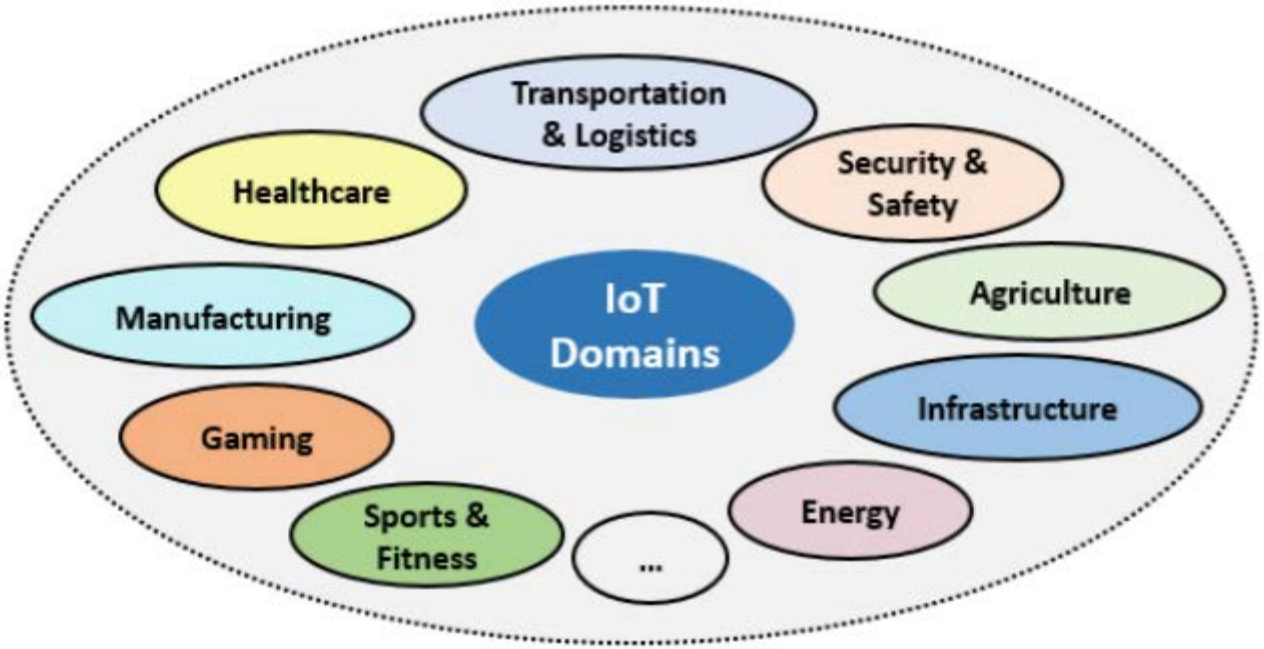


Fig 3: IoT Application Domains

WIoT Domains and Devices

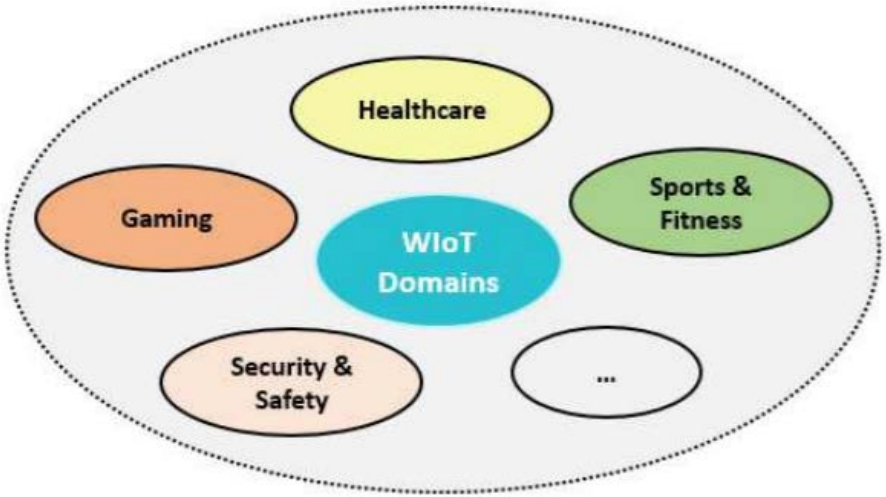
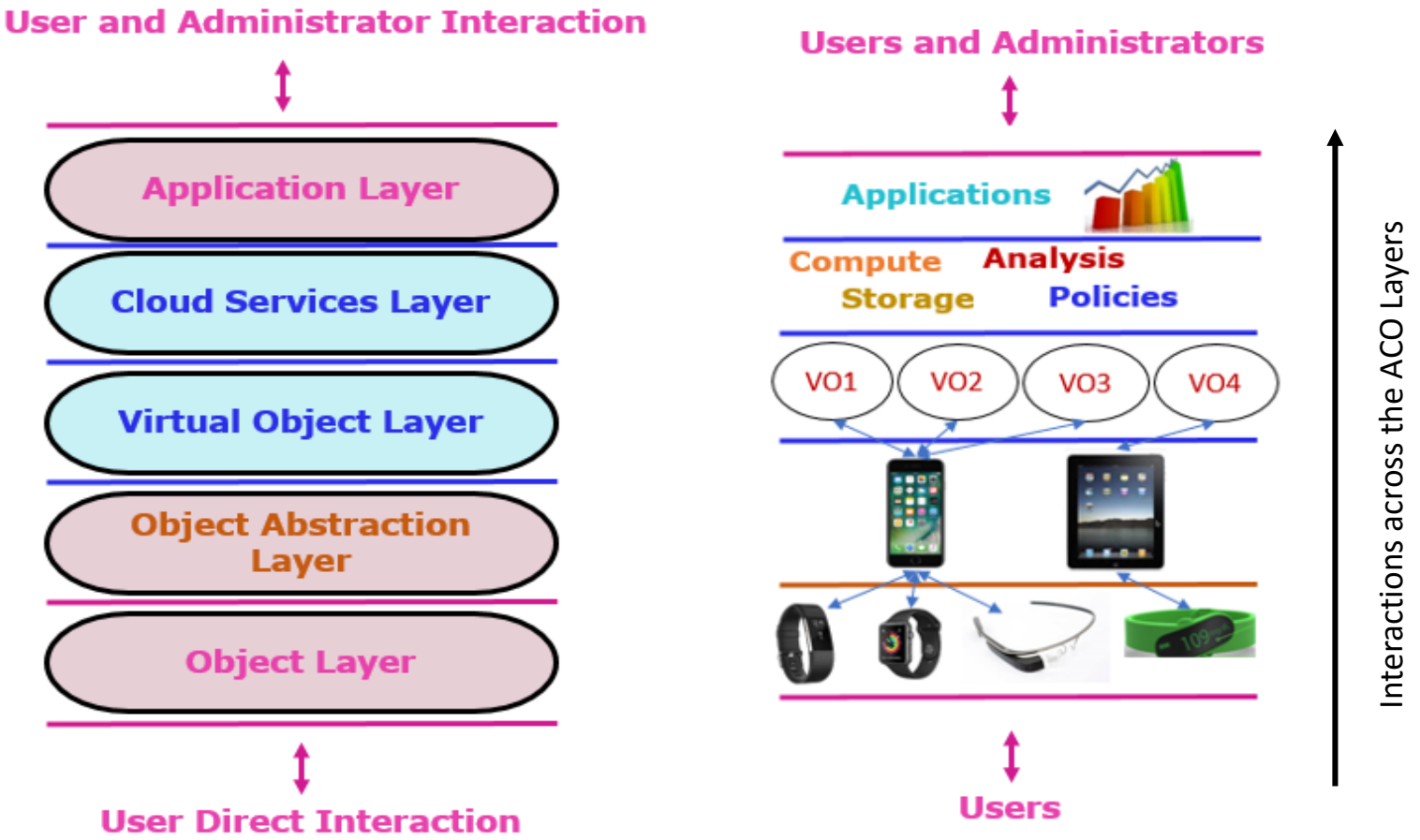


Fig 4: WIoT Application Domains

- ❖ Wearable Devices:
  - ✓ smart watches
  - ✓ smart clothing and accessories
  - ✓ wireless body sensors
  - ✓ …
- ❖ Types of Wearable Devices:
  - ❖ In-Body
  - ❖ On-Body
  - ❖ Around-Body

→ *Wearable devices data – highly privacy sensitive and confidential*
→ *A unified access control framework for CEWIoT securing IoT components and their interactions (communication and data exchange) is still lacking*

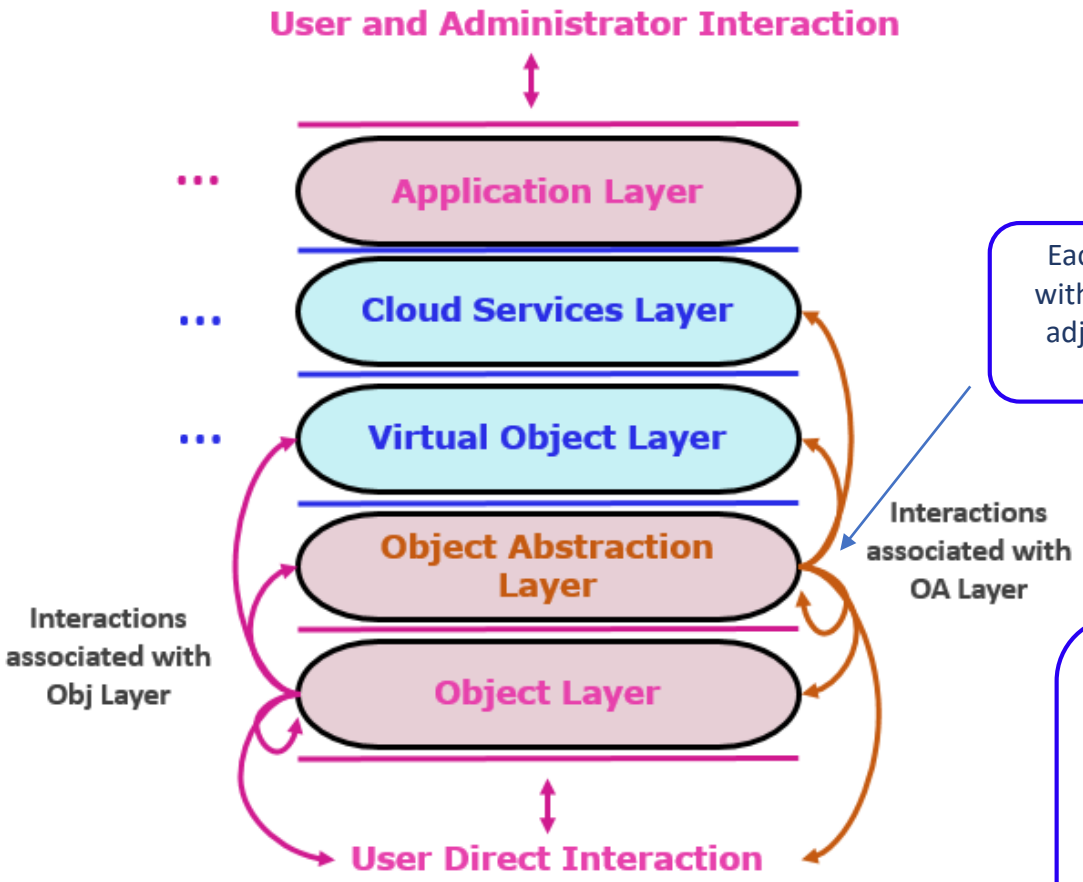
Enhanced ACO Architecture for WIoT



a) Enhanced ACO Architecture for WIoT b) IoT Components in ACO Layers

Fig 5: Enhanced ACO Architecture for WIoT

Access Control (AC) Framework



Each layer can interact with itself and up to two adjacent layers in each direction

Two types of interactions:
- **Direct Interaction** (Interactions with itself and direct adjacent layers)
- **Indirect Interaction** (Interactions with second level of adjacent layers)

Fig 6: Interactions Between ACO Layers

Access Control (AC) Framework (Contd.)

The access control (AC) framework –

- A set of access control models categorized into three main access control categories:
  - Object Access Control models
    - Object Layer and Object Abstraction Layer
  - Virtual Object Access Control models
    - Virtual Object Layer
  - Cloud Access Control models
    - Cloud Services Layer and Applications Layer
- Suitable access control models: Role-Based Access Control (RBAC), Attribute-Based Access Control (ABAC), Relationship-Based Access Control (ReBAC)

Access Control (AC) Framework (Contd.)

AWS-IoTAC Model [3]
- Policy-based access control
- ABAC in limited form
  - Client Attributes
  - Target Attributes

Alshehri and Sandhu [2]
- VO-VO communications
- Operational and Administrative Access Control Models
  - ACLs, CapBAC, RBAC, ABAC

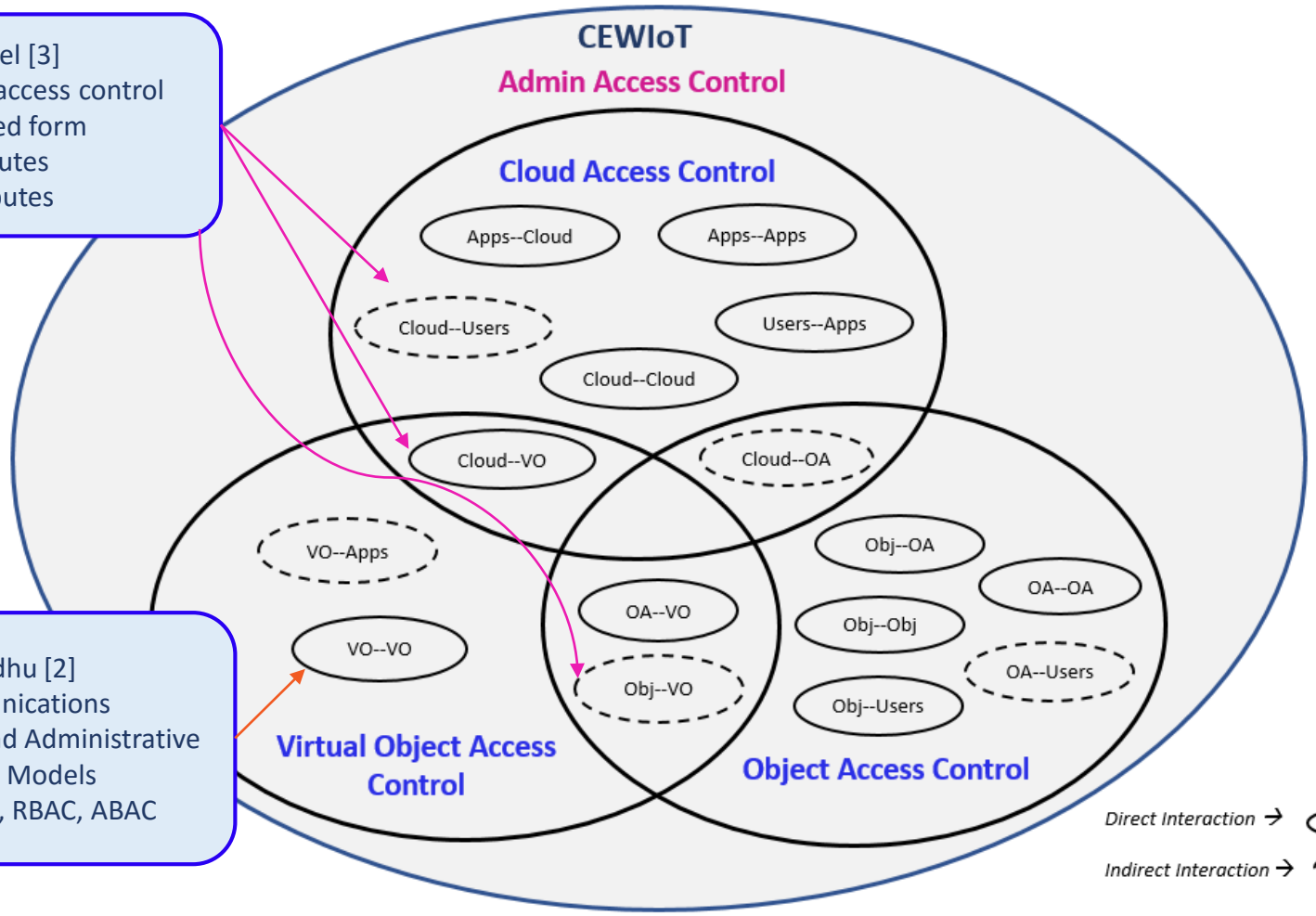


Fig 7: Access Control Framework Based on Interactions Between Different Layers of the ACO Architecture

Types of Access Control Models

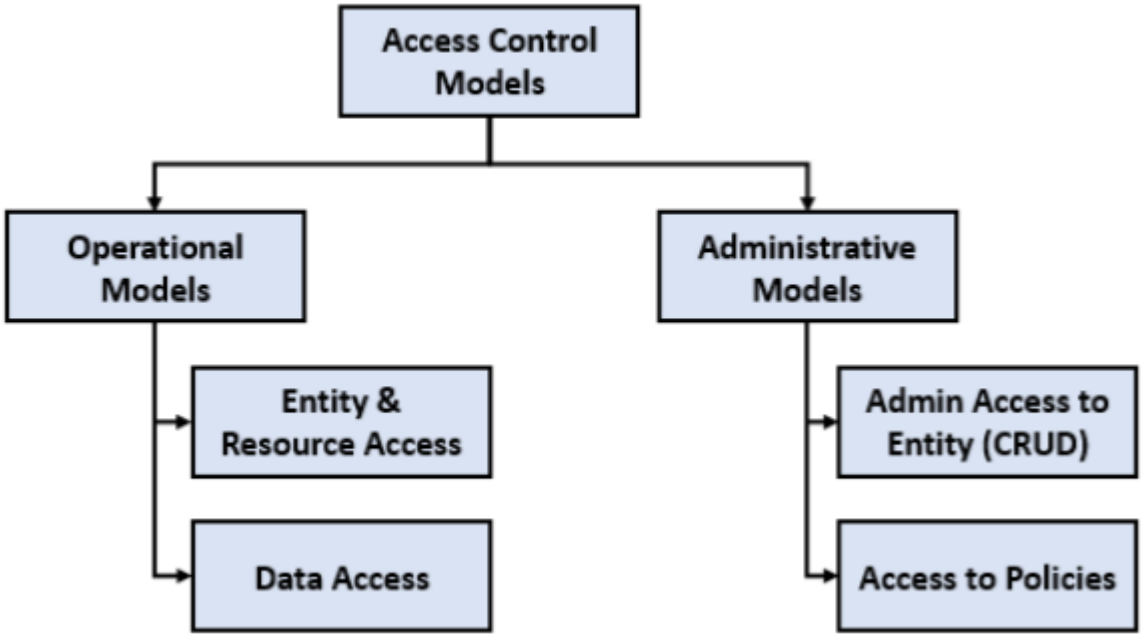


Fig 8: Types of Access Control Models

Use Case

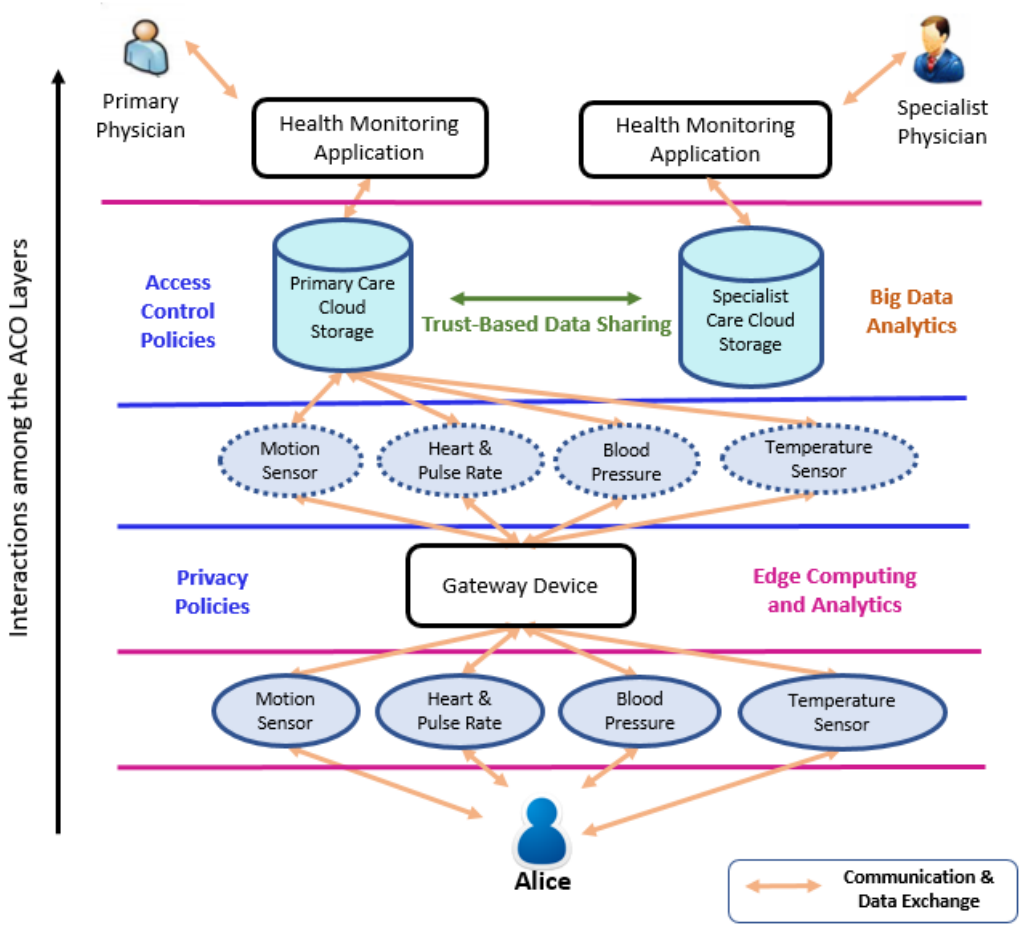


Fig 9: Remote Health and Fitness Monitoring (RHFM) Example

Use Case (Contd.)

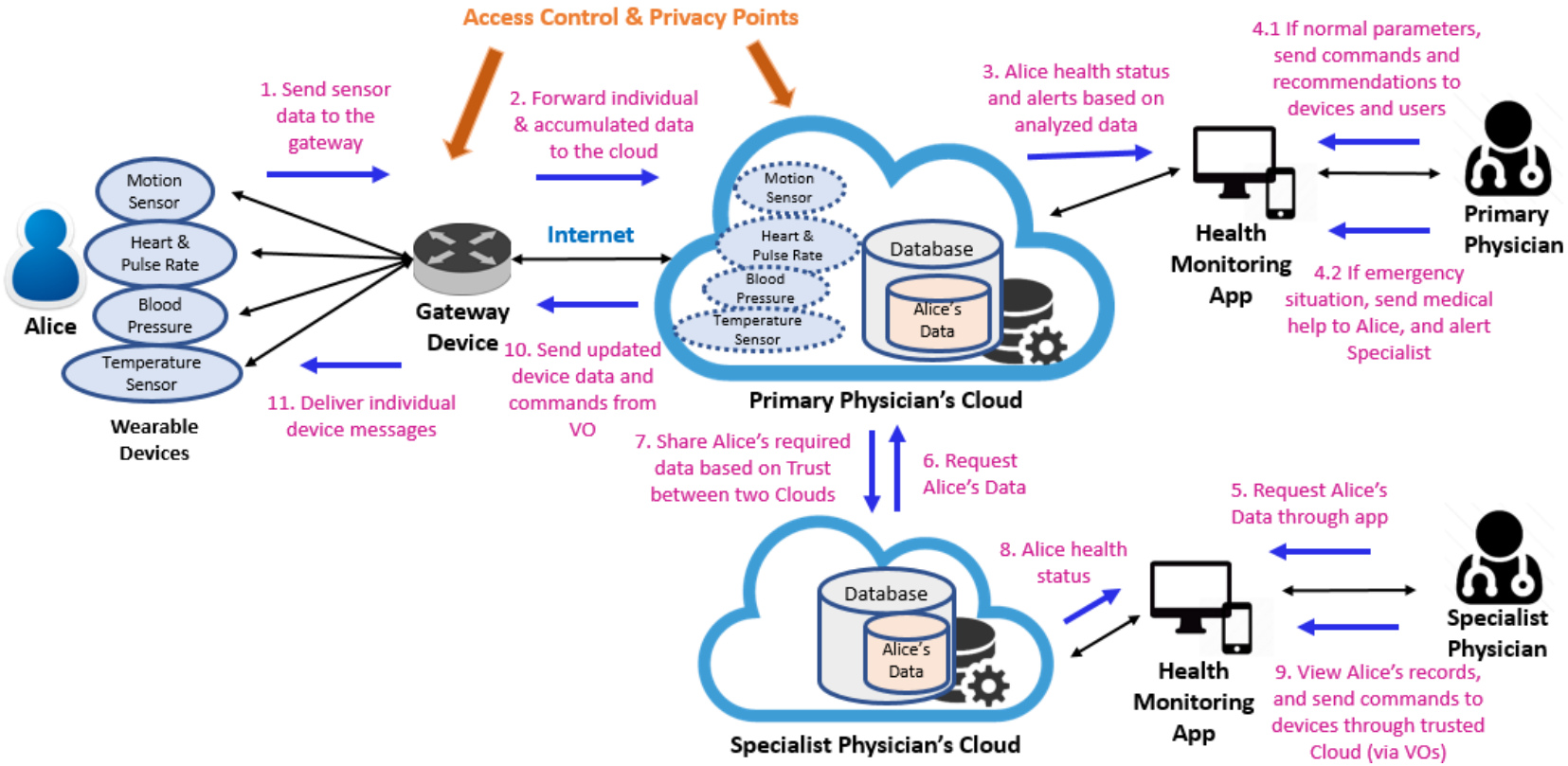
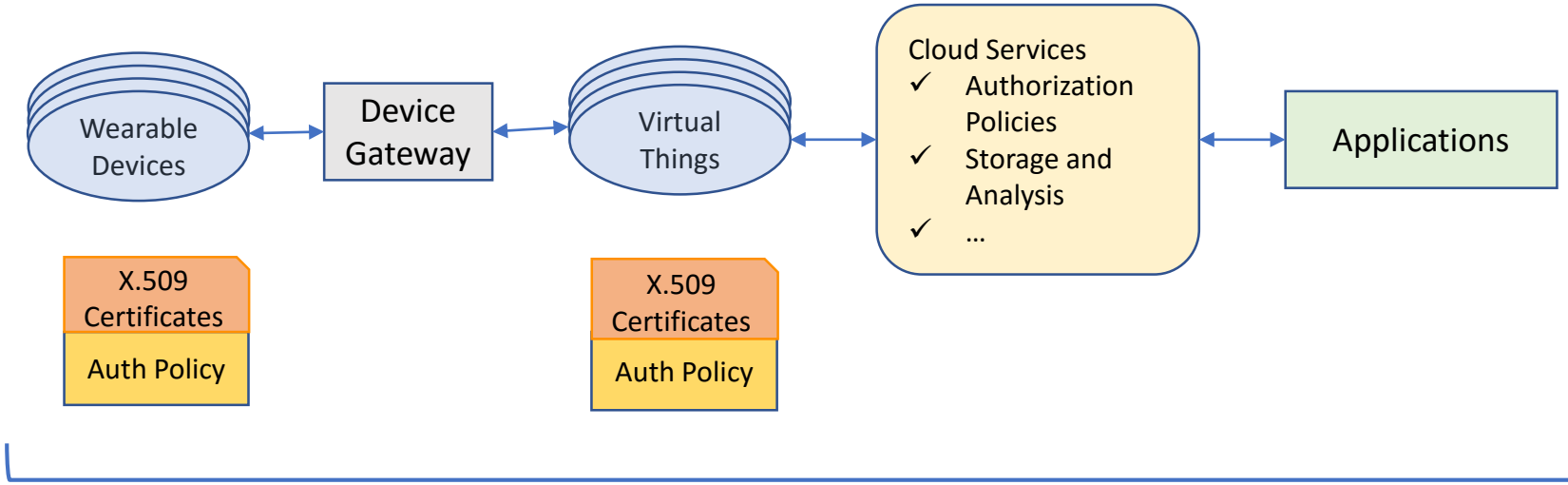


Fig 10: A sequential view of the RHFM Use Case

Proposed Enforcement in AWS IoT

- Based on our previous work [3], we propose a possible enforcement of our use case utilizing AWS IoT platform
- In [3], we configured a smart home use case (with smart sensors, lights, and thermostat) in AWS IoT



AC Framework Objectives & Research Problems

- User-Based Device Authentication
- User-Centric Data Security and Privacy
- Edge Computing in WIoT (Cloudlets)
- Multi-Cloud Architecture for WIoT (Collaboration and Edge Computing)

Conclusion and Future Work

- Developed a conceptual AC framework for cloud-enabled wearable IoT (CEWIoT)
  - Enable development of a family of AC models with fine-grained access control for specific interactions in CEWIoT
- Discussed suitable access control models (e.g., RBAC, ABAC, ReBAC) for different AC categories
- Presented a WIoT use case and its possible implementation in AWS IoT

Future Work:

- Develop Cloud Access Control models (cross-tenant/account, multi-cloud models) – ABAC and other combinations

References

[1] Alshehri, Asma, and Ravi Sandhu. "Access control models for cloud-enabled internet of things: A proposed architecture and research agenda." In *IEEE 2nd International Conference on Collaboration and Internet Computing (CIC)*, pp. 530-538. IEEE, 2016.

[2] Alshehri, Asma, and Ravi Sandhu. "Access Control Models for Virtual Object Communication in Cloud-Enabled IoT." *In 18th International Conference on Information Reuse and Integration (IRI).* IEEE. 2017.

[3] Bhatt, Smriti, Farhan Patwa, and Ravi Sandhu. "Access Control Model for AWS Internet of Things." In *International Conference on Network and System Security*, pp. 721-736. Springer, Cham, 2017.

(…More in the paper)

Thank you!

Questions?