I·C·S
The Institute for Cyber Security

C·SPECC
Center for Security and Privacy Enhanced Cloud Computing

A Perspective on IoT Security

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ESORICS Keynote
September 2022

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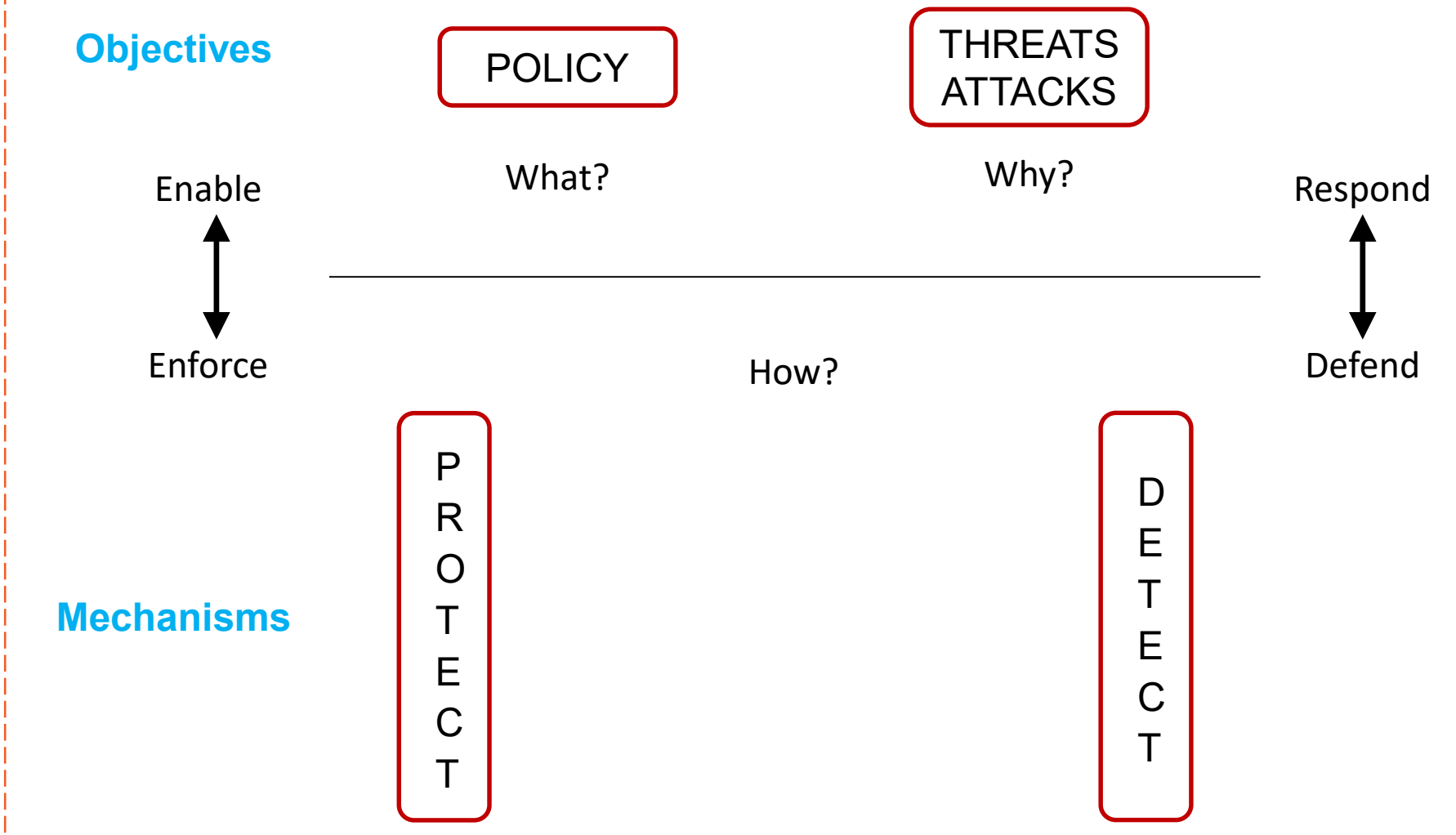
World-Leading Research with Real-World Impact!

UTSA Computer Science

Holistic Cyber Security



Holistic Cyber Security

Objectives

POLICY

THREATS
ATTACKS

What?

Why?

Enable

Enforce

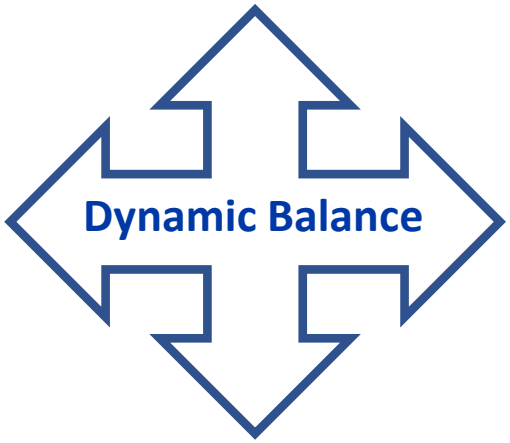
Respond

Defend

How?

Mechanisms

PROTECT



DETECT

Holistic Cyber Security

Holistic Cyber Security

Objectives

Enable

Enforce

Respond

Defend

Mechanisms

Application Context

- IoT
- CPS
- Enterprise
- Cloud
- Social
- Metaverse
- .....

Holistic Cyber Security

Objectives

Enable

Enforce

Respond

Defend

Mechanisms

IoT Use Cases

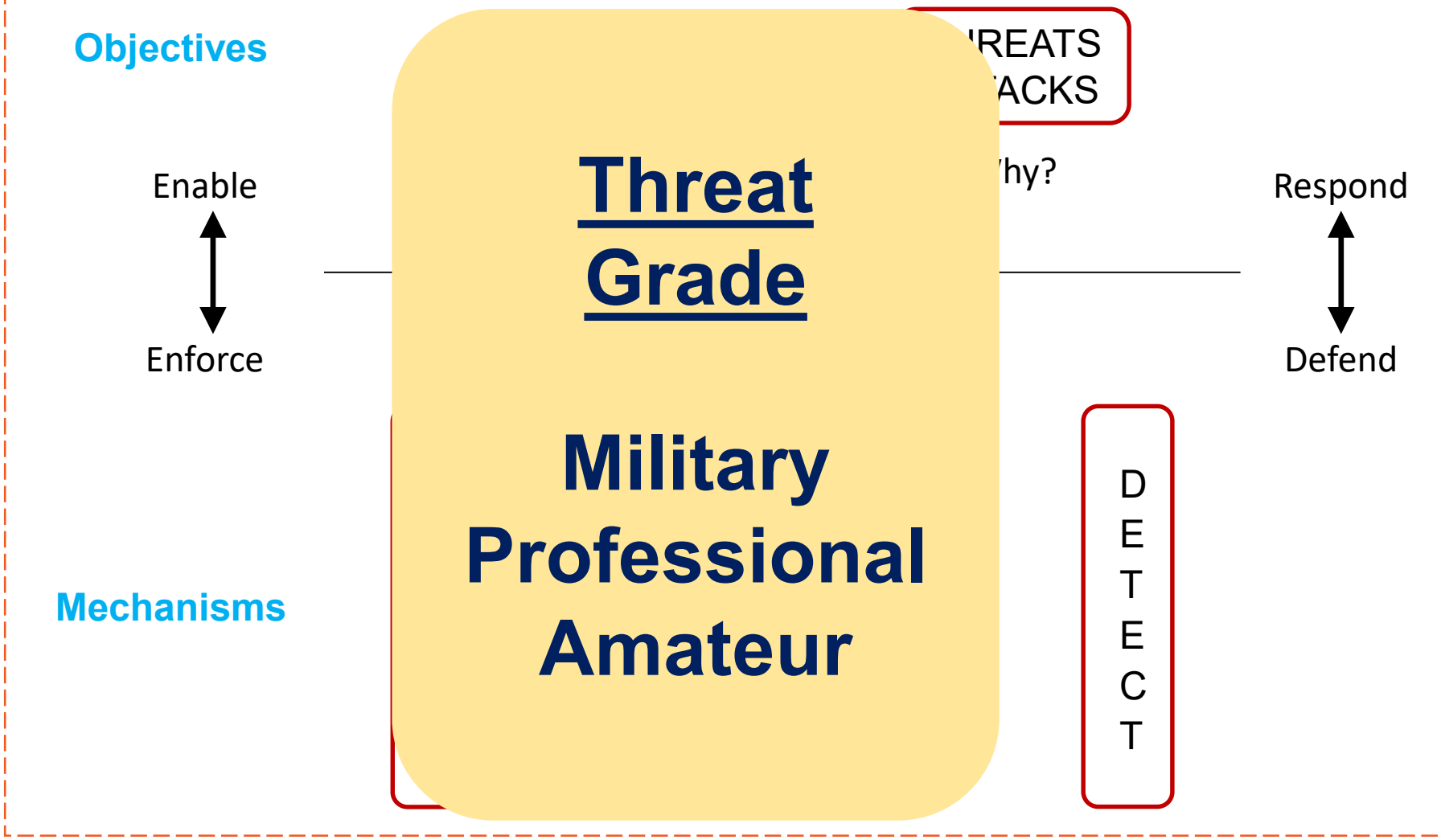
Smart Homes

Wearable IoT

Smart Health

Smart Cars

…….


Objectives
REATS
ACKS
hy?
Enable
Enforce
Respond
Defend
Threat Grade
Military
Professional
Amateur
Mechanisms
D
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Holistic Cyber Security

Obje

Threat Grade

Military
Professional
Amateur

Security Posture

Military
Professional
Amateur

pond

end

Mec

Threat Grade	Security Posture	Example
Military	Military	Nuclear Strike
Professional	Professional	ATMs
Amateur	Amateur	Your Exercise

Holistic Cyber Security

Obj

Threat Grade

Military
Professional
Amateur

Security Posture

Military
Professional
Amateur

pond

end

Mec

Joint Work with Doctoral Graduates

- Mehrnoosh Shakarami, *Operation and Administration of Access Control in IoT Environments*, Spring 2022.
- Safwa Ameer, *User-To-Device Access Control Models for Cloud-Enabled IoT With Smart Home Case Study*, Summer 2021.
- Maanak Gupta, *Secure Cloud Assisted Smart Cars and Big Data: Access Control Models and Implementation*, Fall 2018.
- Smriti Bhatt, *Attribute-Based Access and Communication Control Models for Cloud and Cloud-Enabled IoT*, Summer 2018.
- Asma Alshehri, *Access Control Models for Cloud-Enabled Internet of Things*, Spring 2018.

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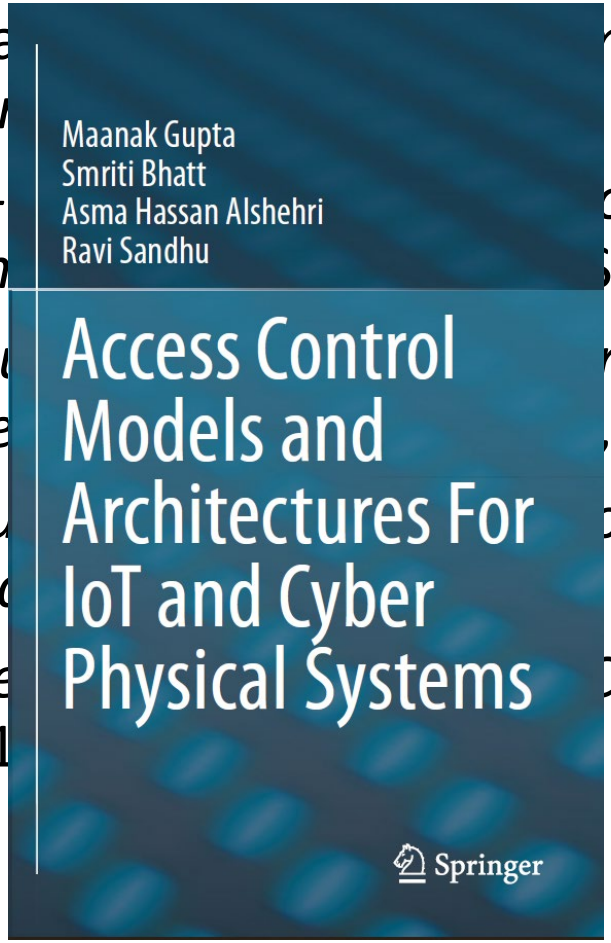
- Smriti Bhatt, *Attribu ommunication Control Models for Cloud and*mmer 2018.
- Asma Alshehri, *Acce Cloud-Enabled Internet of Things*, Spring 201



Cloud-enabled IoT
CE-IoT

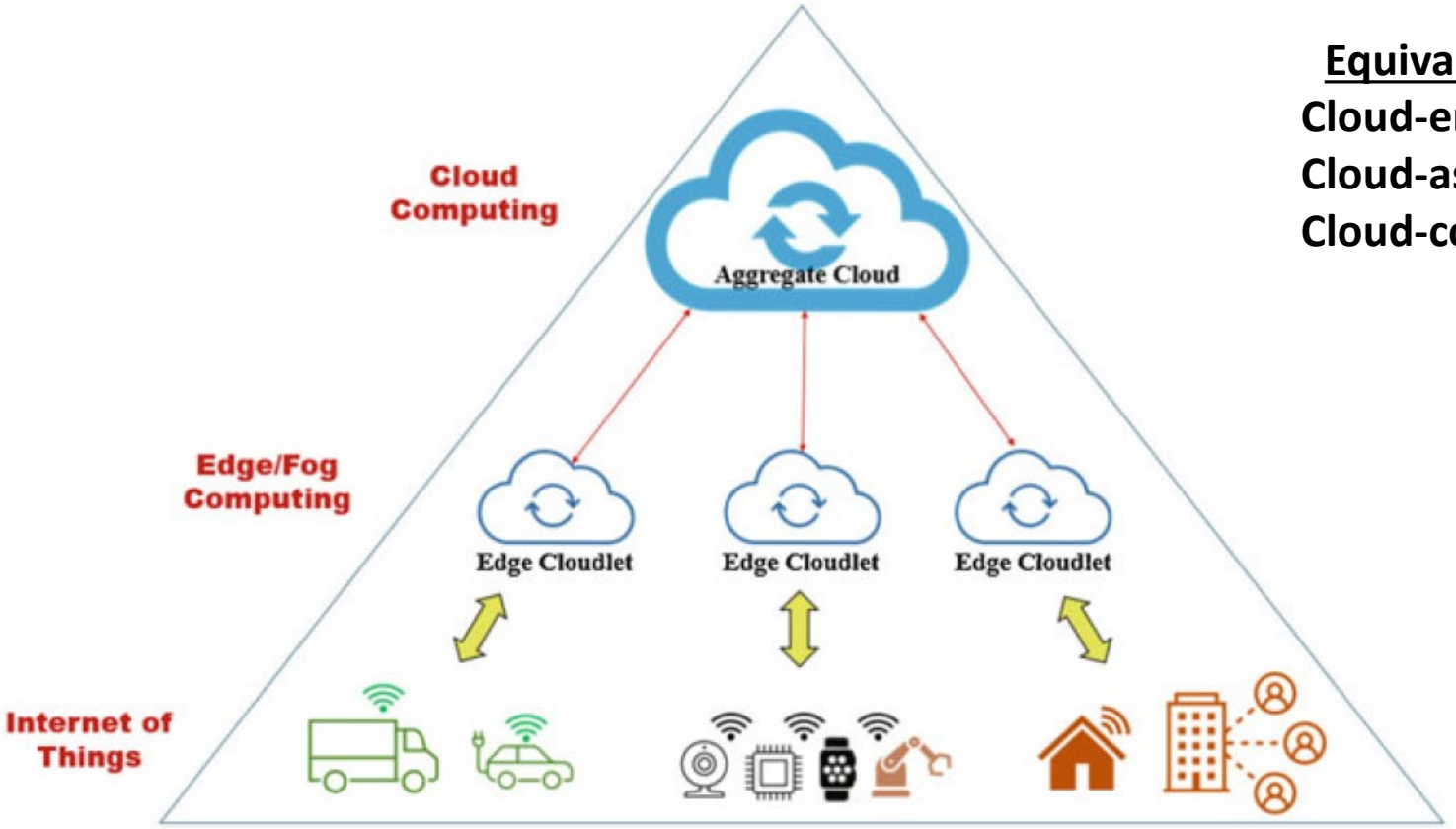


Fig. 1.5 A cloud and edge enabled IoT and CPS vision

Equivalently
Cloud-enabled
Cloud-assisted
Cloud-coupled

CE-IoT Architectures

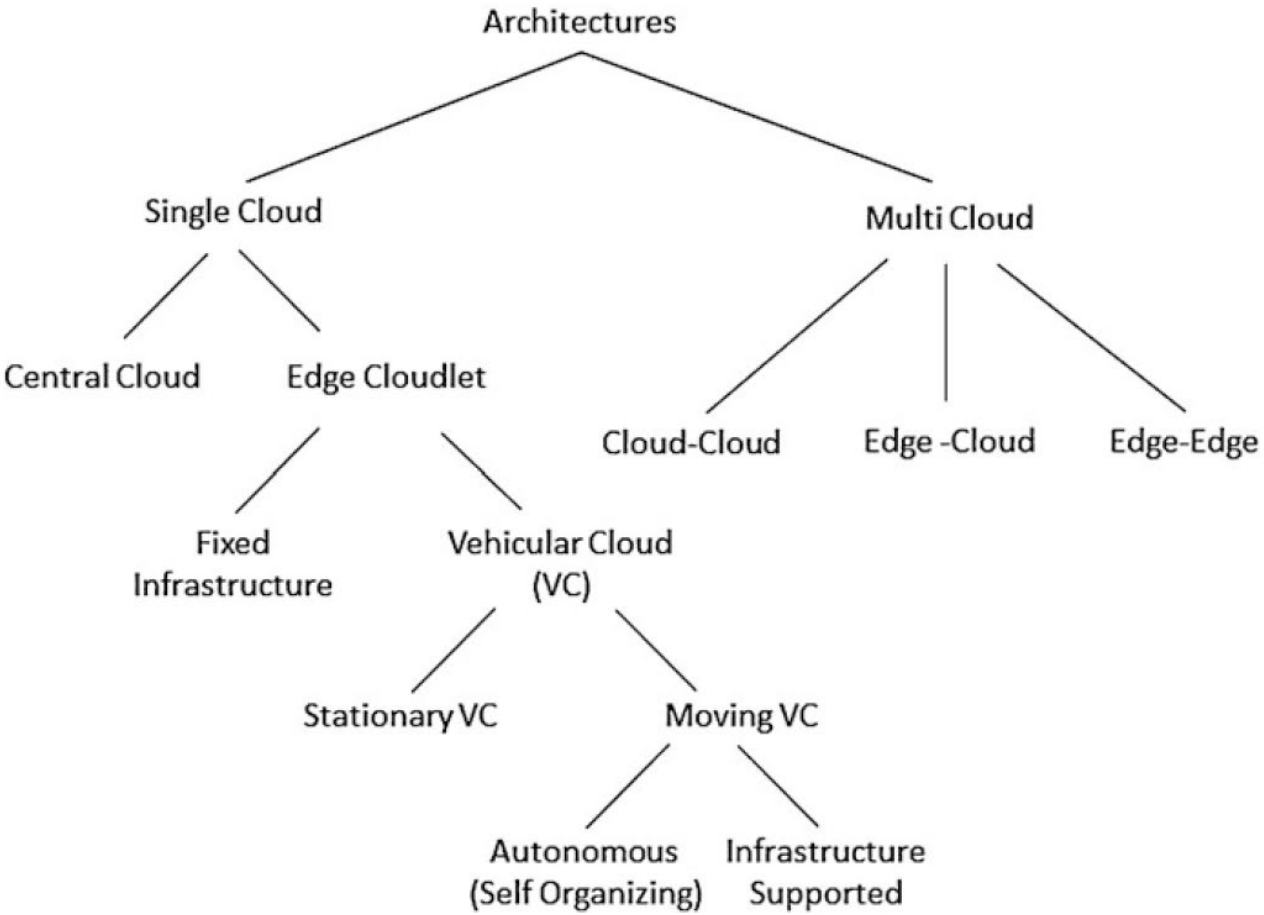


Fig. 2.3 Various cloud and edge architectures for dynamic environments

CE-IoT Basic Architectures

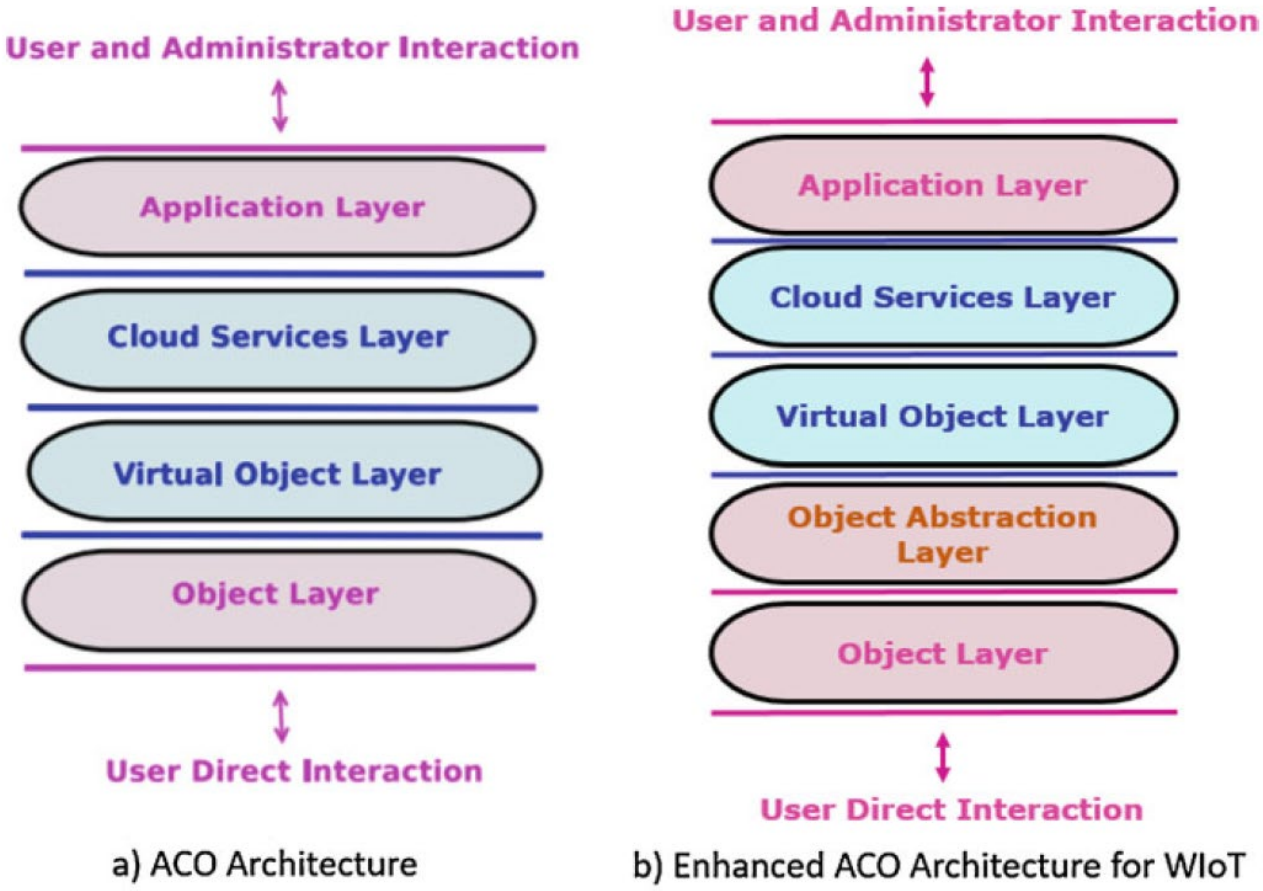
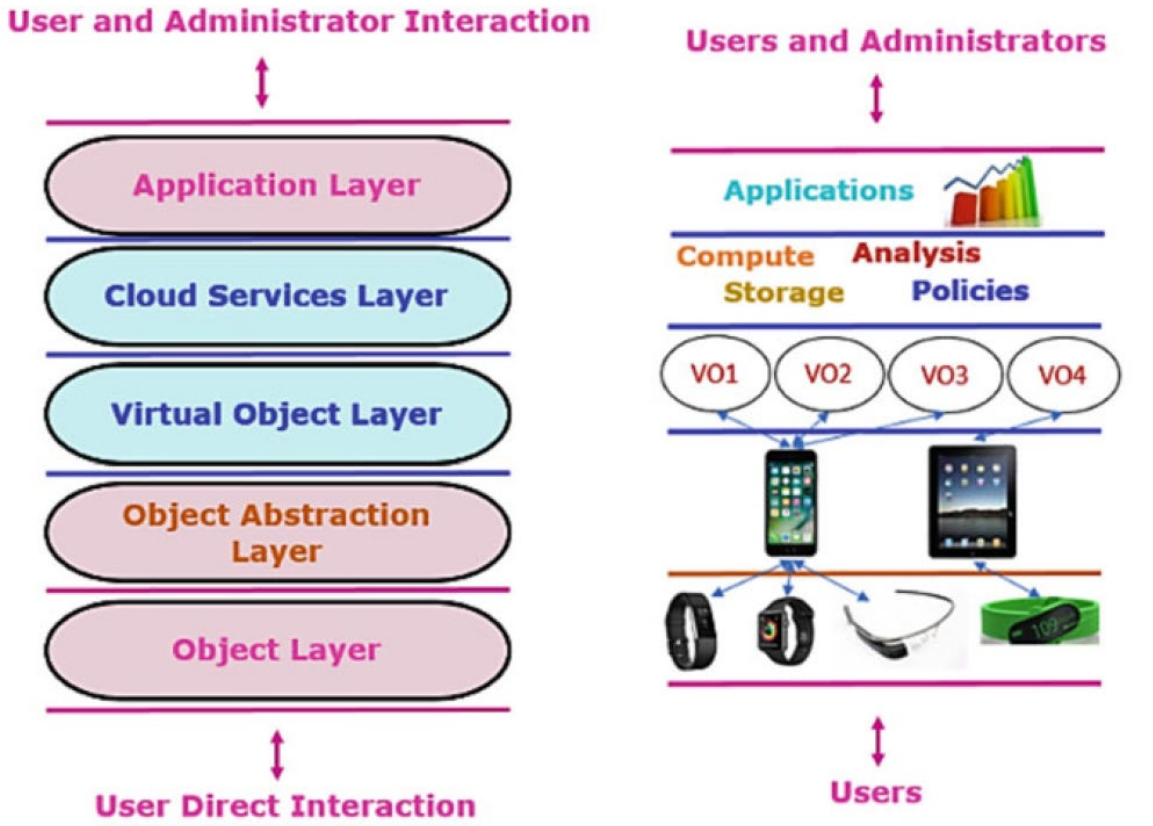


Fig. 7.1 Access control oriented (ACO) and enhanced ACO CE-IoT architectures

CE-IoT for Wearable IoT (WIoT)



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

Fig. 2.5 An enhanced ACO architecture with edge computing capabilities

CE-IoT for Smart Health

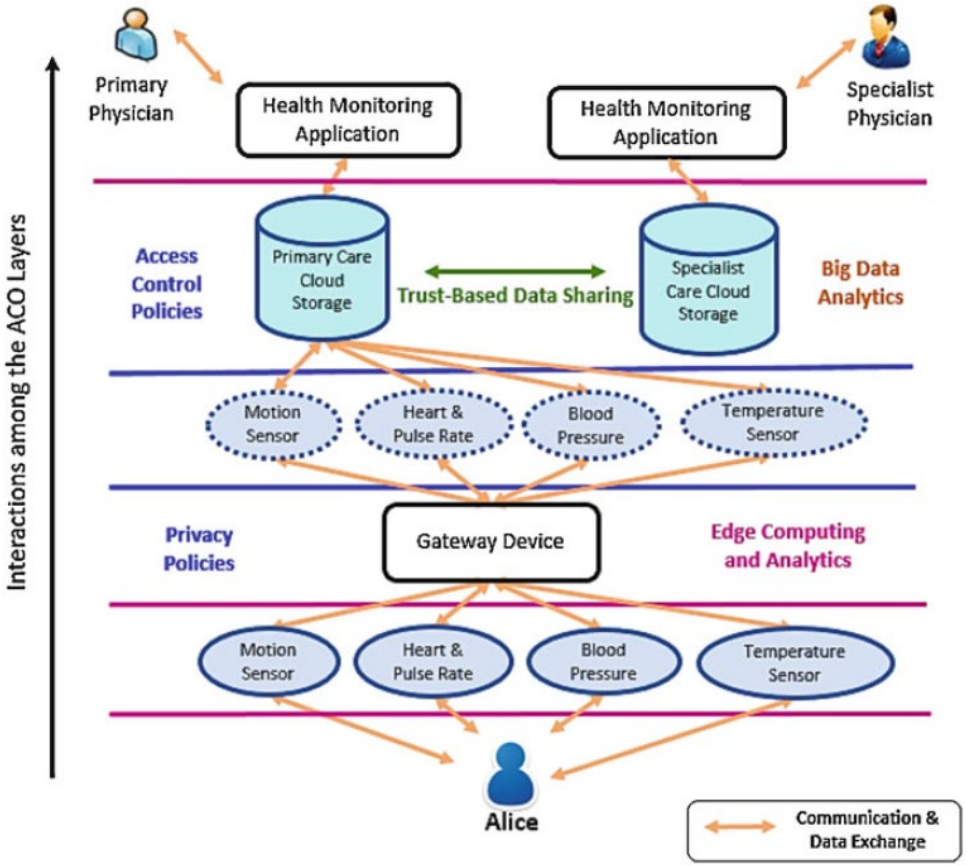
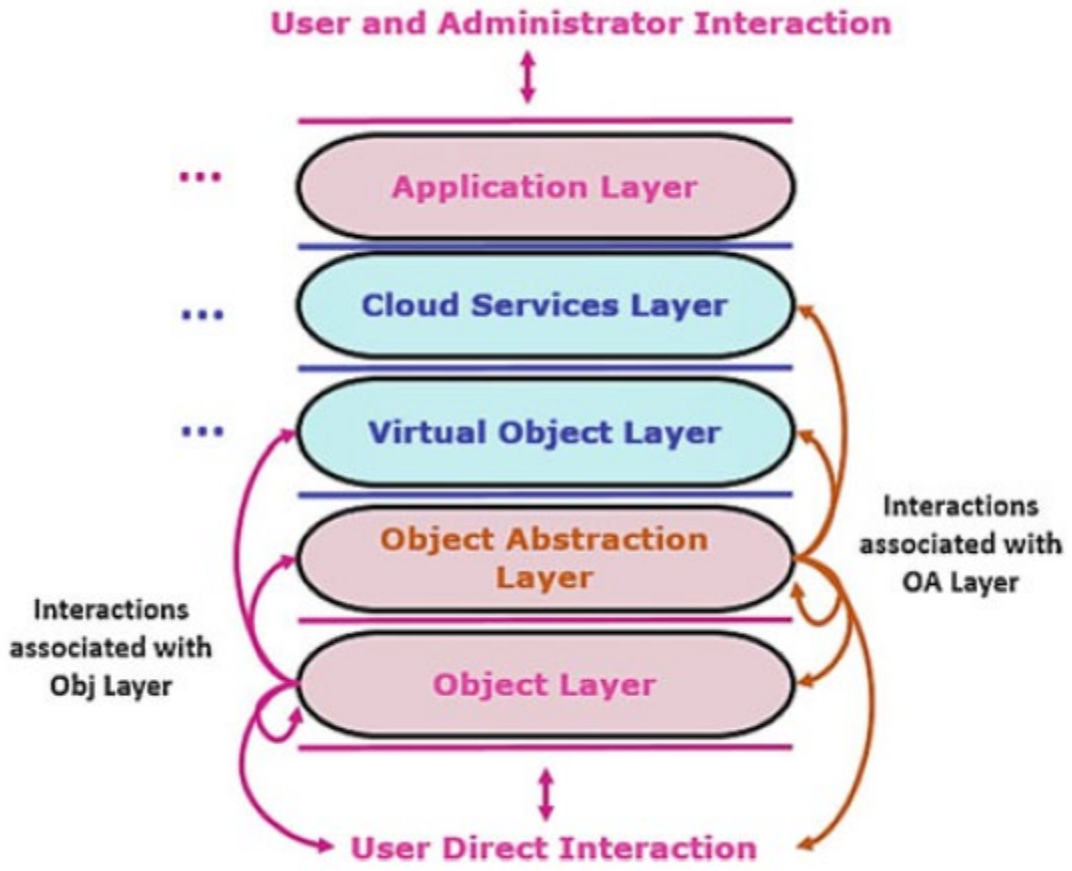


Fig. 2.7 A remote patient monitoring (RPM) usecase with enhanced ACO layers

CE-IoT Interactions

Fig. 3.1 Interactions of entities between enhanced ACO layers



CE-IoT Access Control Framework

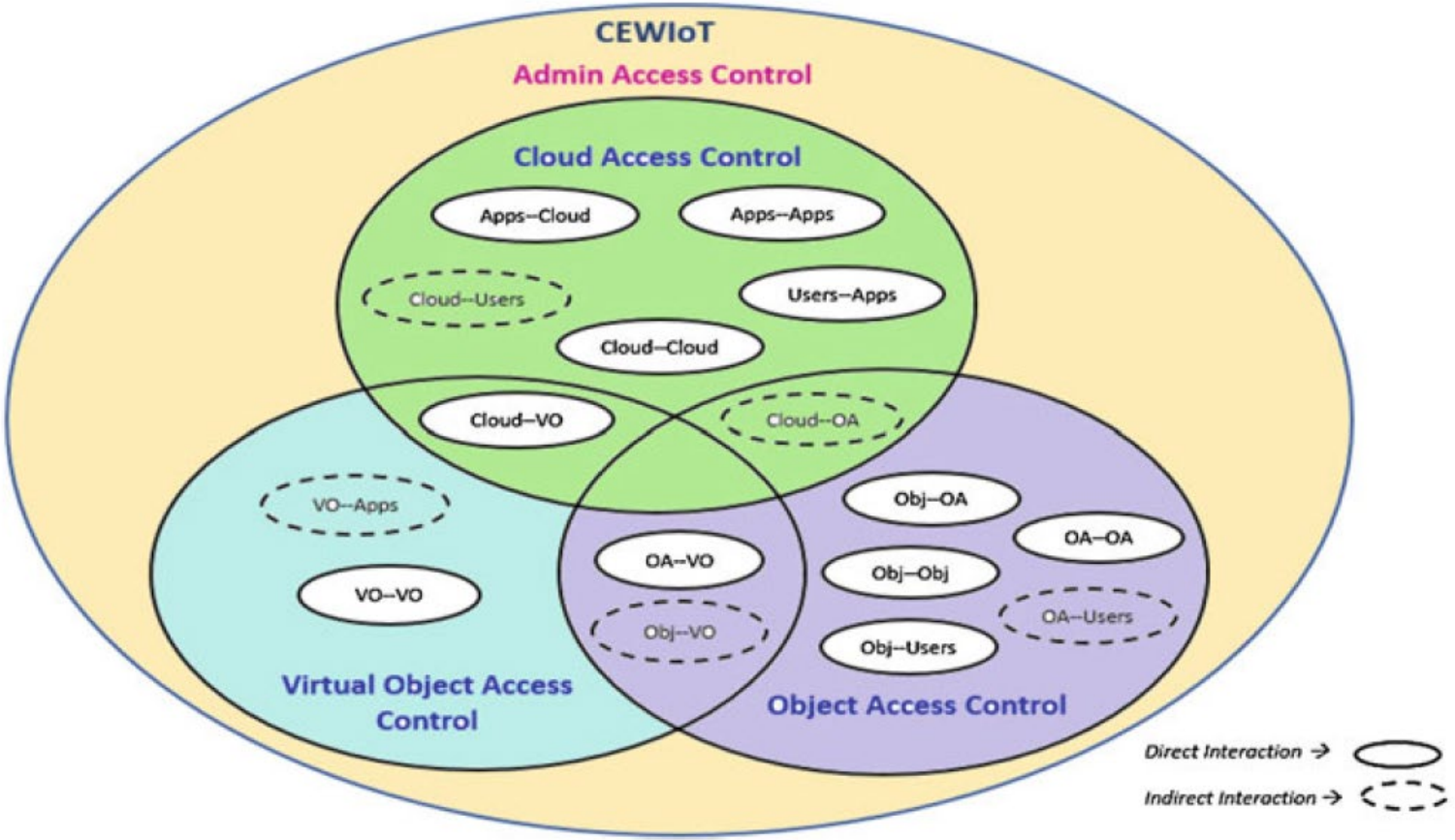


Fig. 3.2 Access control framework based on interactions in the enhanced ACO architecture

CE-IoT Communication Control

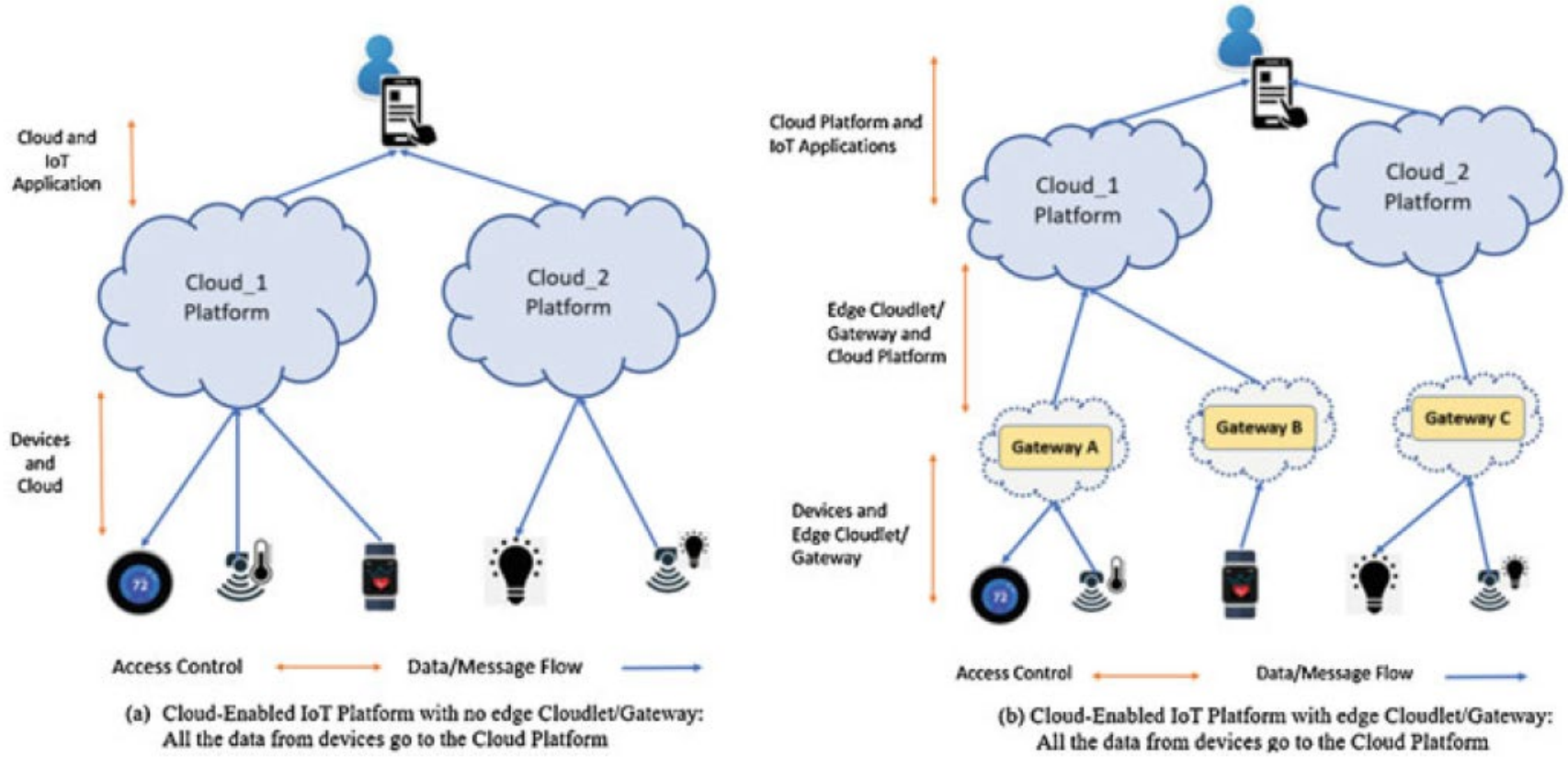


Fig. 7.2 Access and communication control shown in different CE-IoT architectures

CE-IoT Communication Control

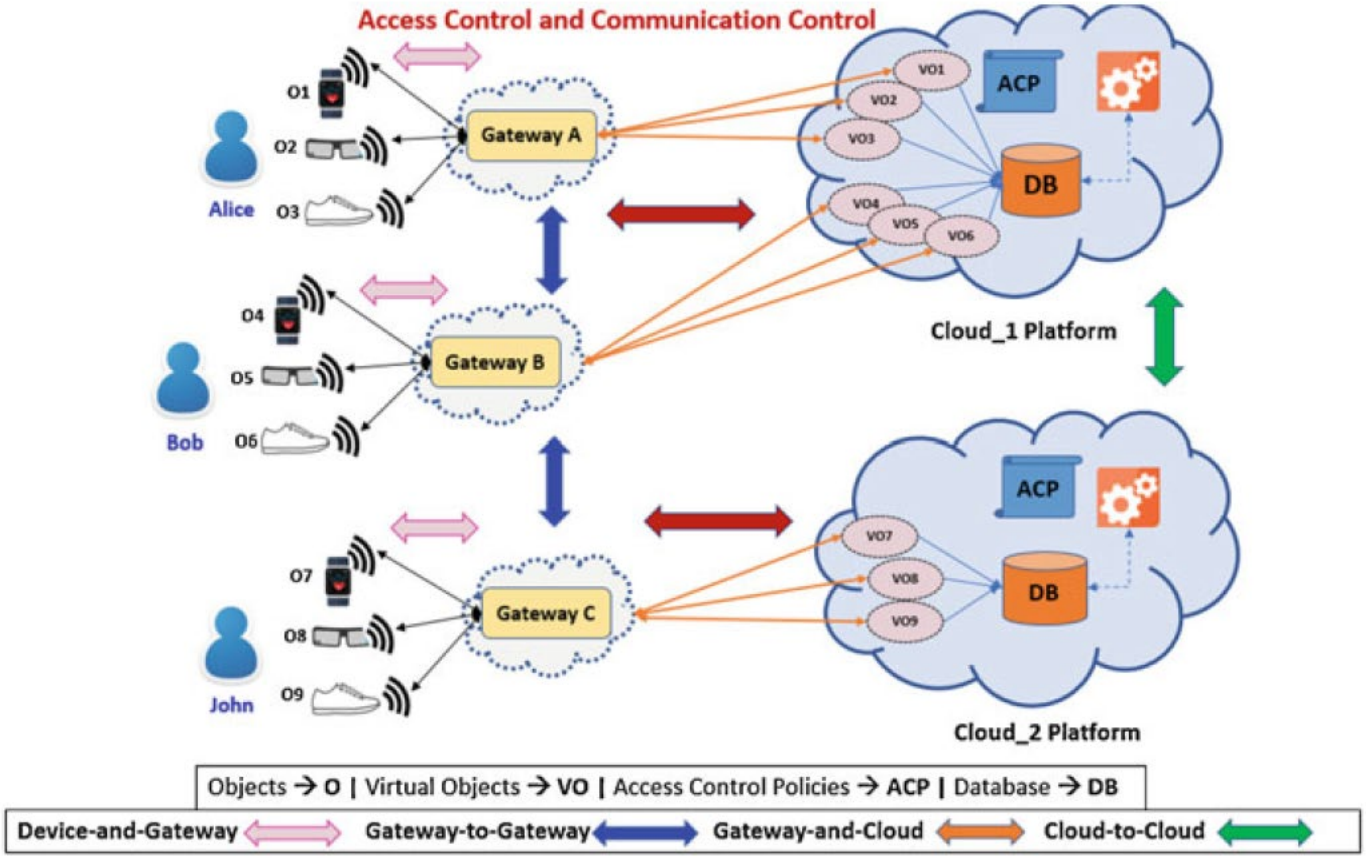


Fig. 7.3 Access control and communication control requirements in CE-IoT

CE-IoT
Communication Control

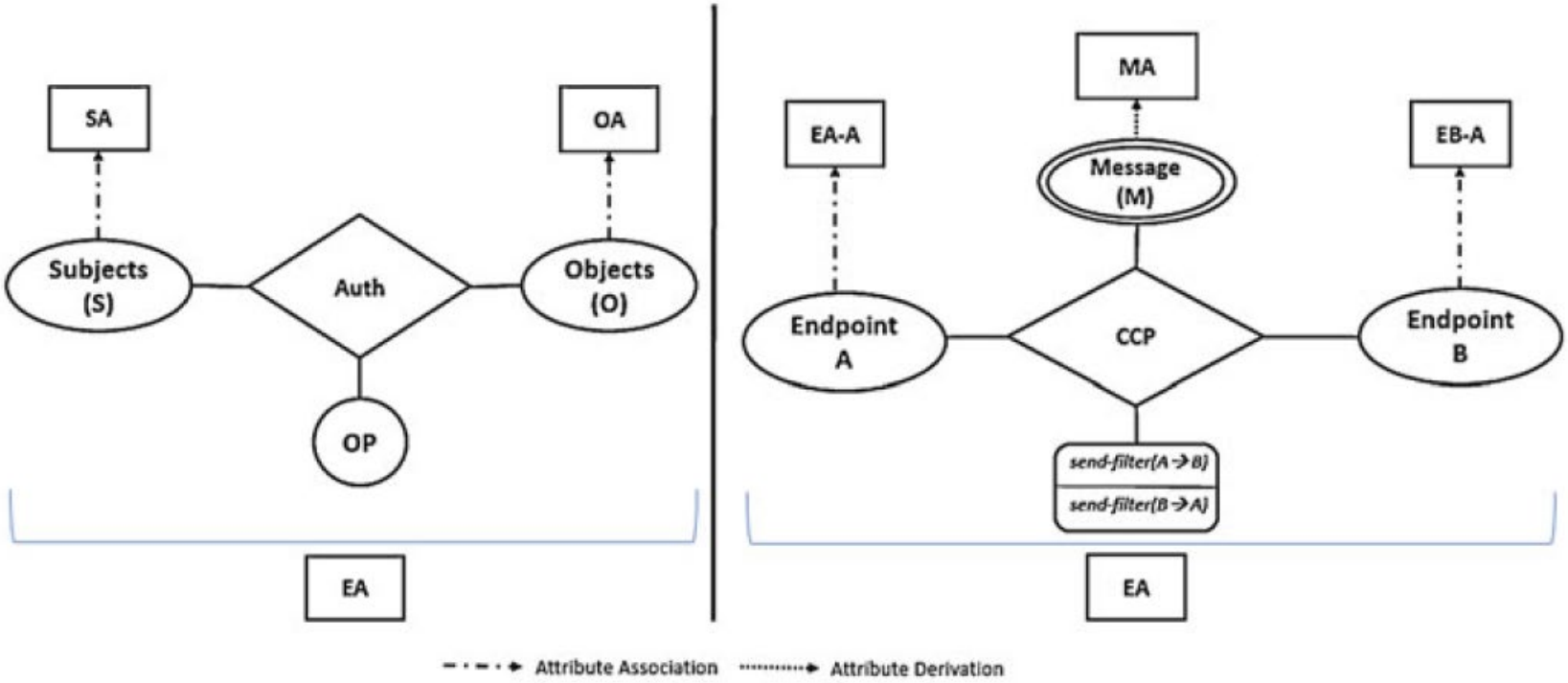
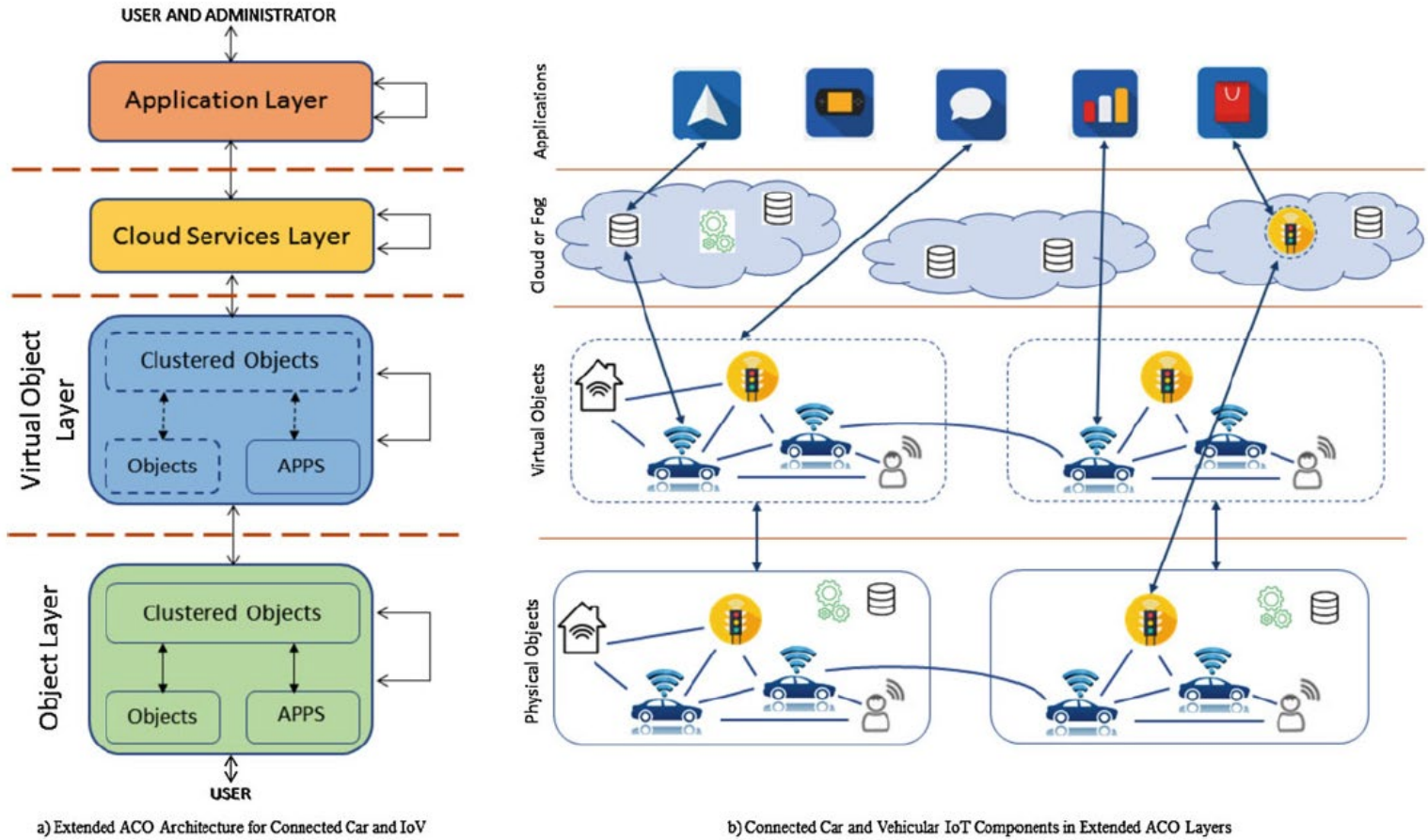


Fig. 7.4 Attribute-based access control vs. attribute-based communication control

CE-IoT for Smart Cars



a) Extended ACO Architecture for Connected Car and IoV

b) Connected Car and Vehicular IoT Components in Extended ACO Layers

Fig. 2.6 Extended ACO architecture for reflecting clustered objects and interactions

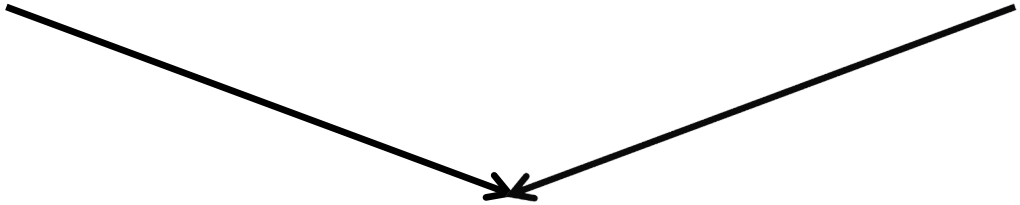
CE-IoT for Smart Cars Dynamic Groups

Fig. 6.2 Groups hierarchy with multiple levels

Access Control

Discretionary Access Control (DAC)
1970

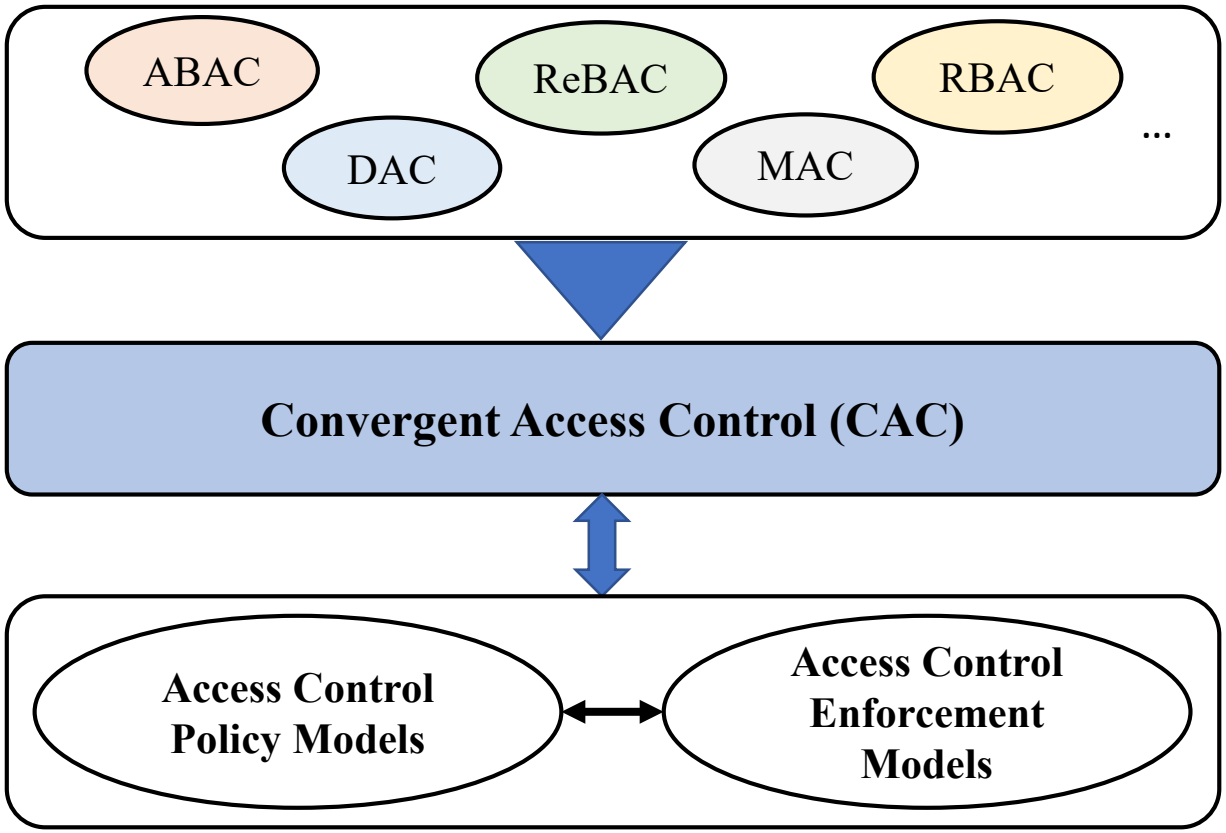
Mandatory Access Control (MAC)
1970



Role Based Access Control (RBAC)
1995

Attribute Based Access Control (ABAC)
Relationship-Based Access Control (ReBAC)
Usage Control (UCON)
2020s (Hopefully)

Access Control Research Convergence



Application Context

This slide prepared by Smriti Bhatt

Joint Work with Doctoral Graduates

- Mehrnoosh Sha … *tration of Access Control in IoT En …*
- Safwa Ameer, *U … odels for Cloud-Enabled IoT Witl …* ner 2021.
- Maanak Gupta, … *rs and Big Data: Access Control M …* 2018.
- Smriti Bhatt, *Ati … unication Control Models for Cloud …* er 2018.
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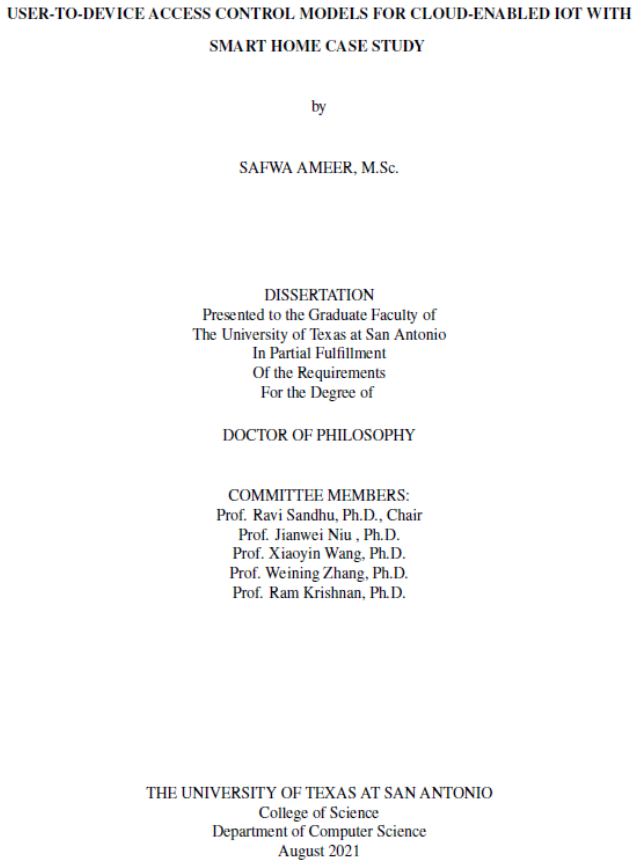

USER-TO-DEVICE ACCESS CONTROL MODELS FOR CLOUD-ENABLED IOT WITH SMART HOME CASE STUDY

by

SAFWA AMEER, M.Sc.

DISSERTATION
Presented to the Graduate Faculty of
The University of Texas at San Antonio
In Partial Fulfillment
Of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY

COMMITTEE MEMBERS:
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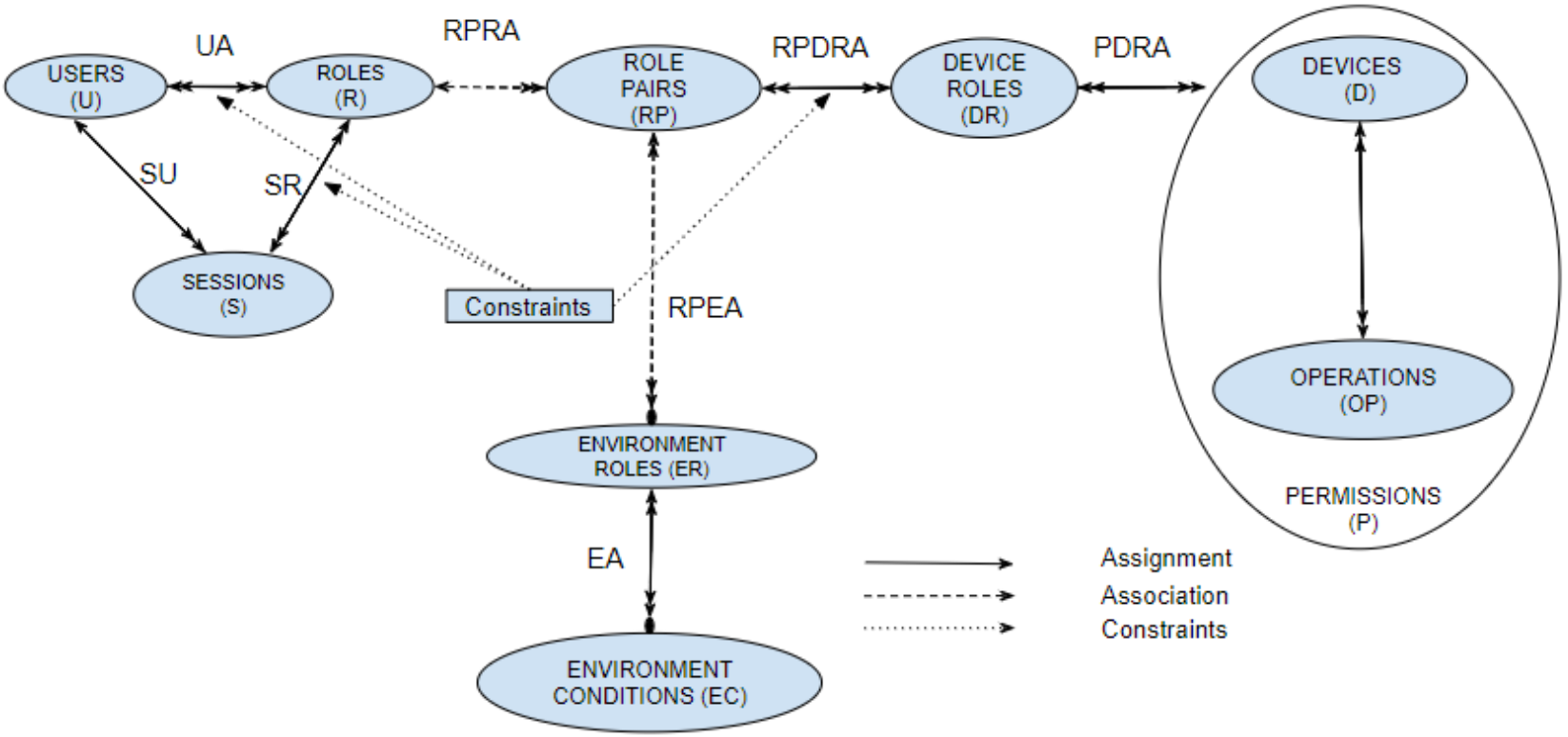
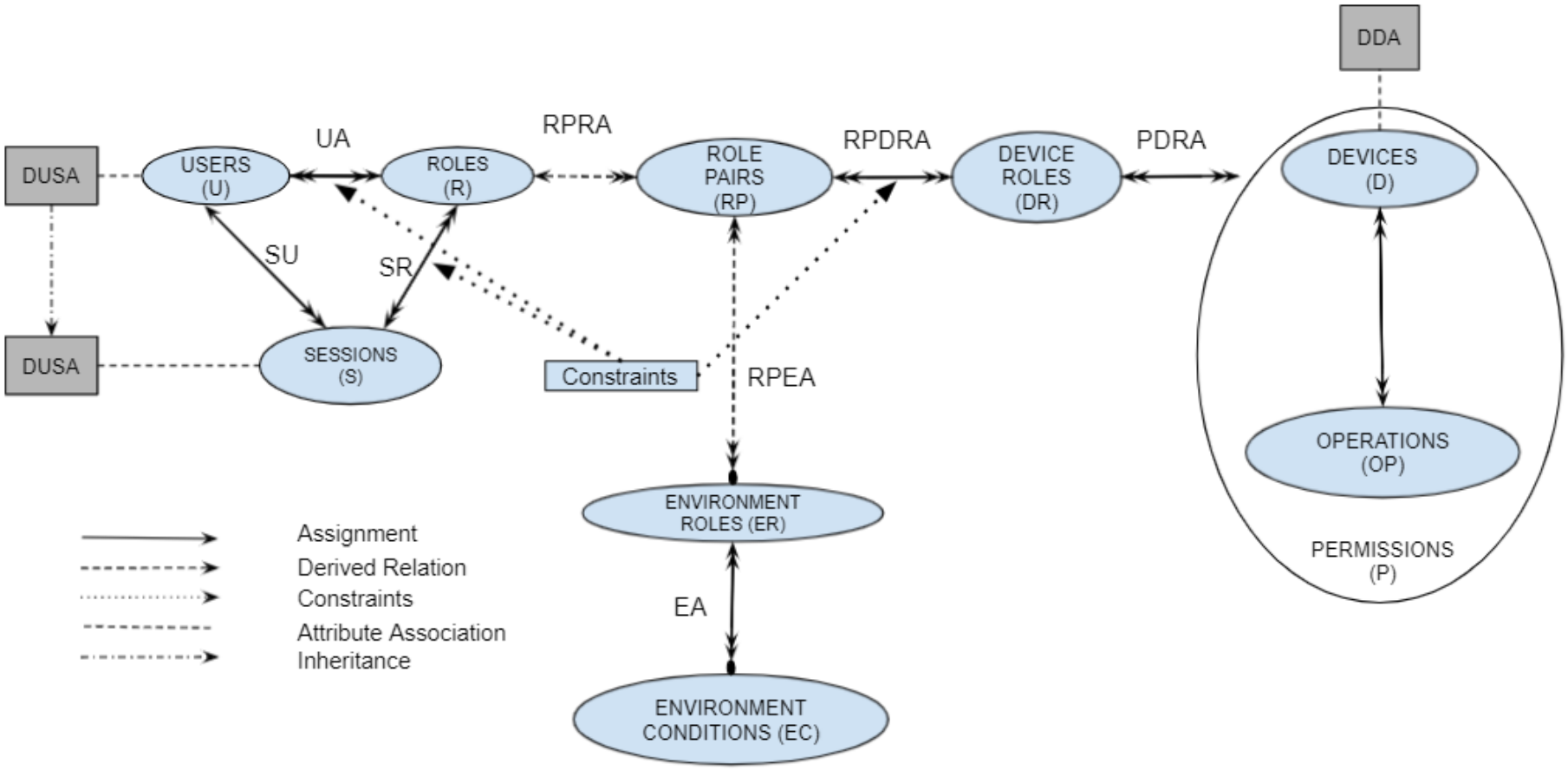
Prof. Xiaoyin Wang, Ph.D.
Prof. Weining Zhang, Ph.D.
Prof. Ram Krishnan, Ph.D.

THE UNIVERSITY OF TEXAS AT SAN ANTONIO
College of Science
Department of Computer Science
August 2021

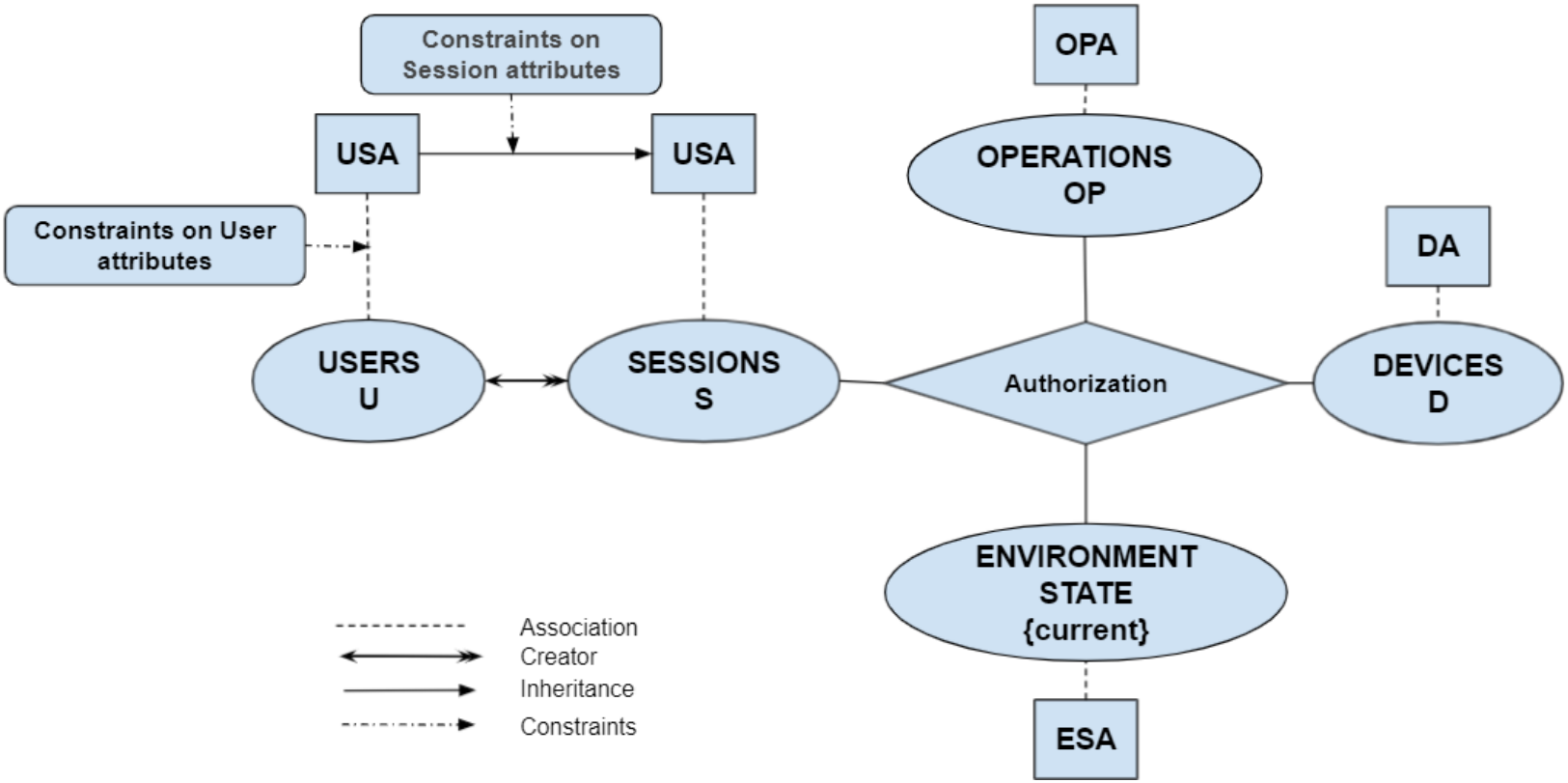
Smart Home IoT EGRBAC (Extended Generalized RBAC)



Smart Home IoT $\mathrm{HyBAC_{RC}}$ (Hybrid AC Role-Centric)



Smart Home IoT HABAC (Home ABAC)



Smart Home IoT $\mathrm{HyBAC}_{\mathrm{AC}}$ (Hybrid AC Attribute-Centric)

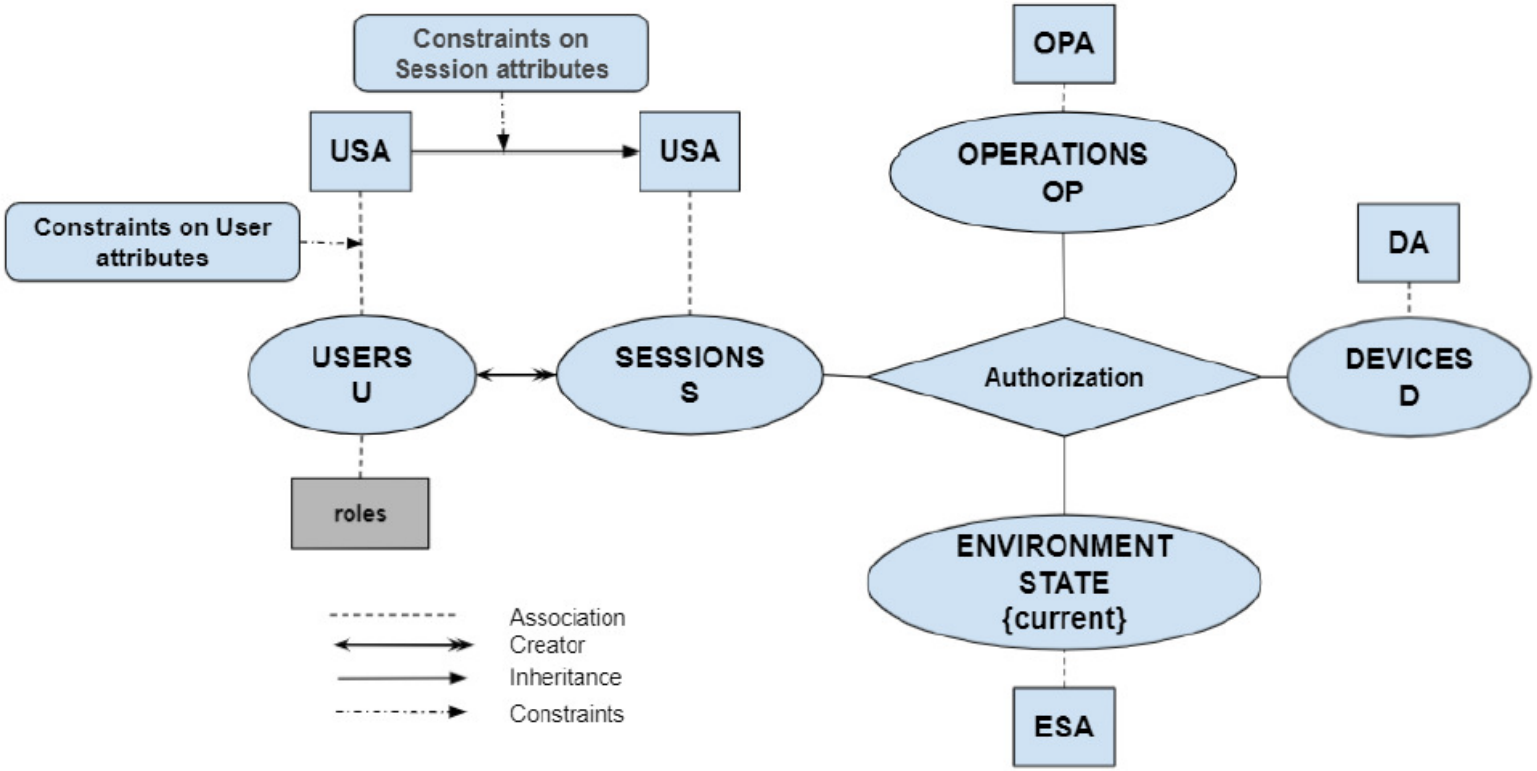
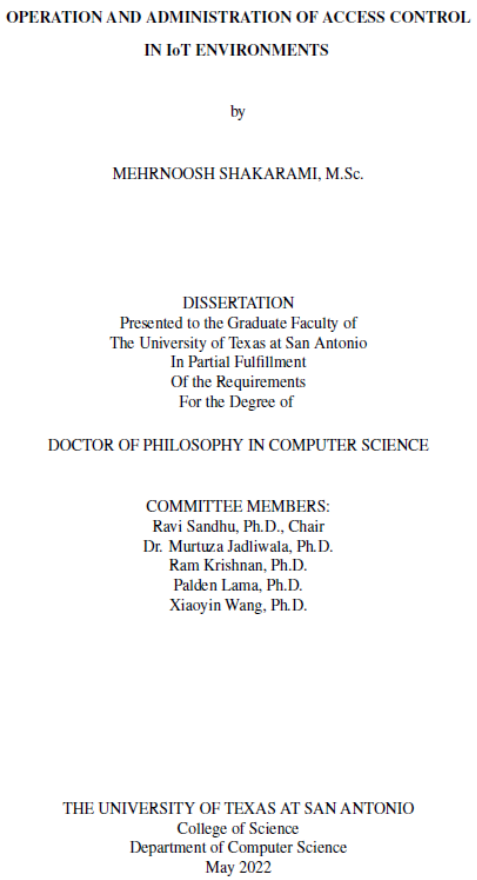


Figure 5.4: Smart Home IoT $HyBAC_{AC}$ Model

Joint Work with Doctoral Graduates

- Mehrnoosh Shakarami, *Op* *Access Control in IoT Environments*
- Safwa Ameer, *User-To-Dev* *Cloud-Enabled IoT With Smart Ho*
- Maanak Gupta, *Secure Clo* *Data: Access Control Models and*
- Smriti Bhatt, *Attribute-Bas* *Control Models for Cloud and Cloua*
- Asma Alshehri, *Access Con* *Internet of Things*, Spring 2018.



OPERATION AND ADMINISTRATION OF ACCESS CONTROL
IN IoT ENVIRONMENTS

by

MEHRNOOSH SHAKARAMI, M.Sc.

DISSERTATION
Presented to the Graduate Faculty of
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Of the Requirements
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DOCTOR OF PHILOSOPHY IN COMPUTER SCIENCE

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THE UNIVERSITY OF TEXAS AT SAN ANTONIO
College of Science
Department of Computer Science
May 2022

Device-to-Device ABAC (Communication Control)

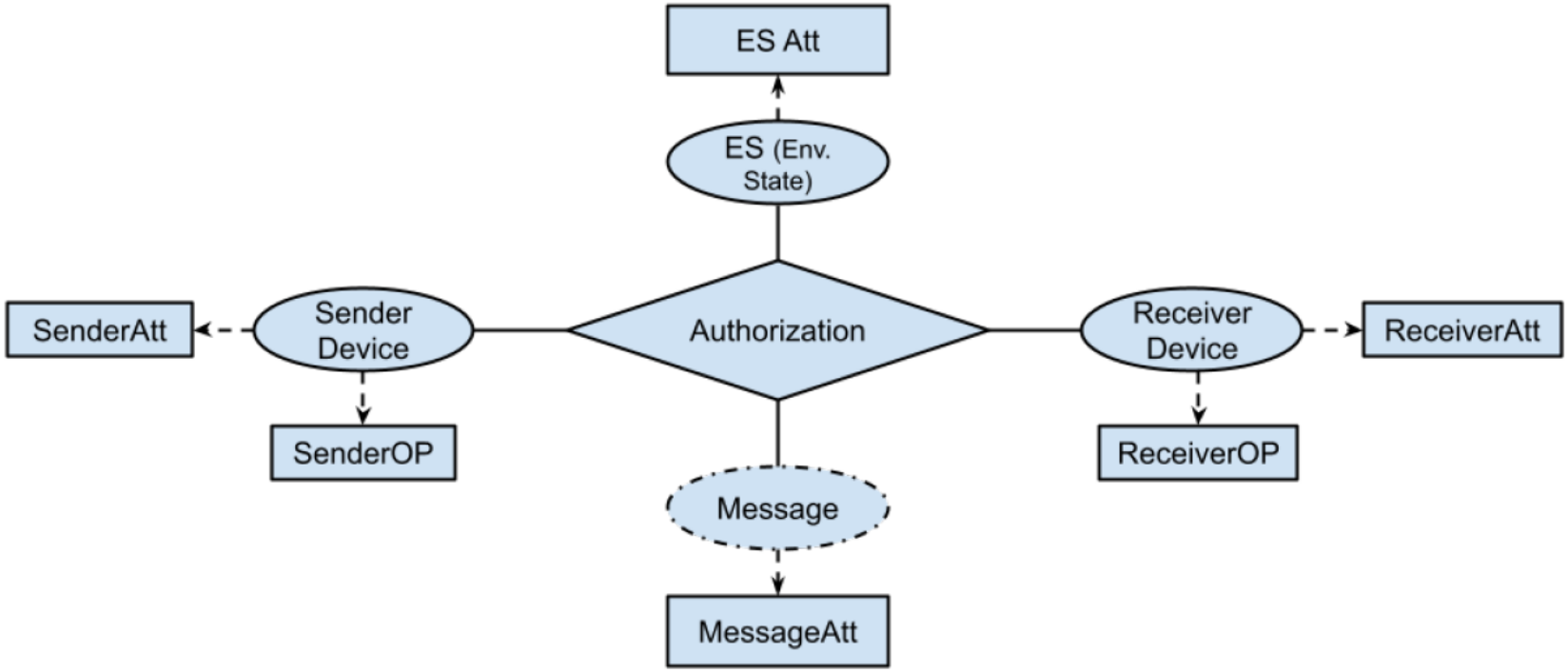

Figure 5.1: Device-to-Device ABAC Model

Scenario Driven Device-to-Device ABAC

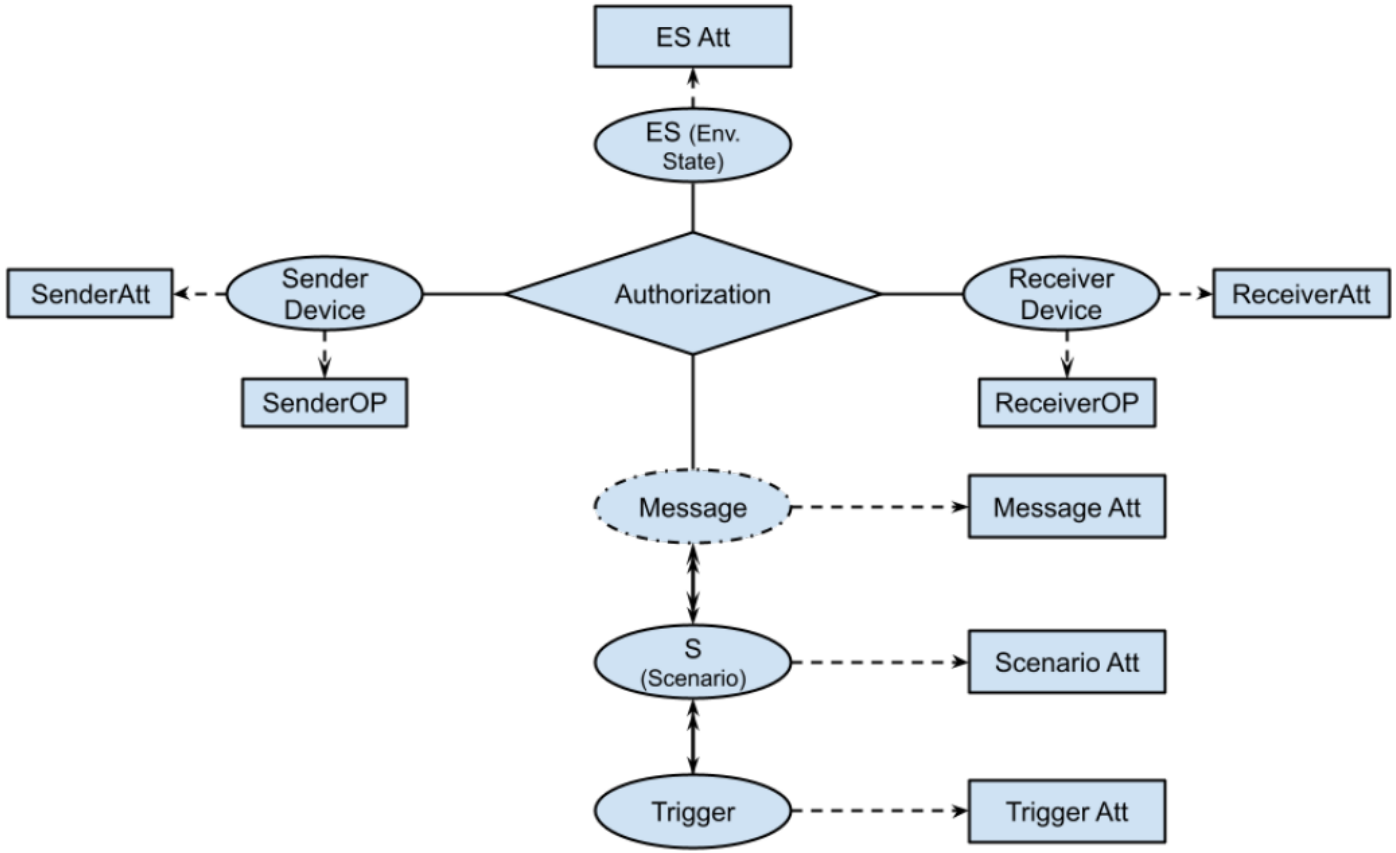

Figure 5.3: Device-to-Device Scenario-Driven ABAC Model

Take Aways

- Meaningful IoT is necessarily Cloud-Enabled
  Equivalently: Cloud-Assisted, Cloud-Coupled
- Motivated by Professional Grade threats
- Need convergence of access control models:
  RBAC, ABAC, ReBAC, UCON ….
- IoT requires traditional access control (actor to target) as well as communication control (sender to receiver)

- Future/Ongoing work:
  - Integration with Zero Trust concepts
  - Application of Machine Learning
  - Integration with Detection technologies
  - Integration with Policy technologies
  - Integration with Response technologies
  - Administration models
  - …..