

Secure Cloud Assisted Smart Cars

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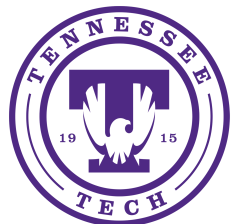
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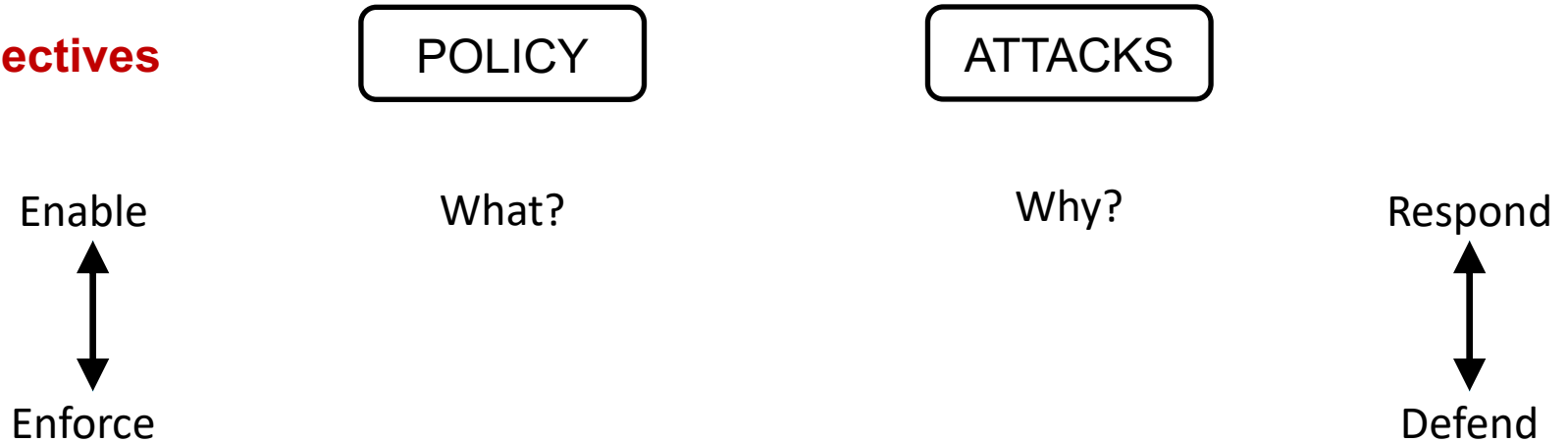
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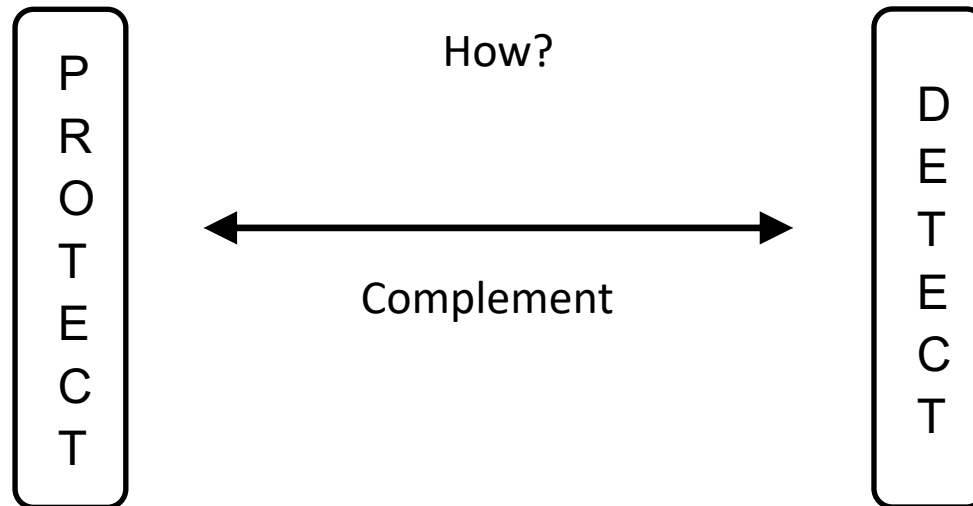


Cyber Security Landscape

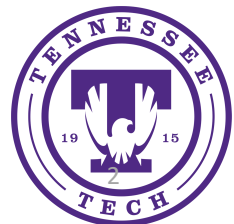
Objectives



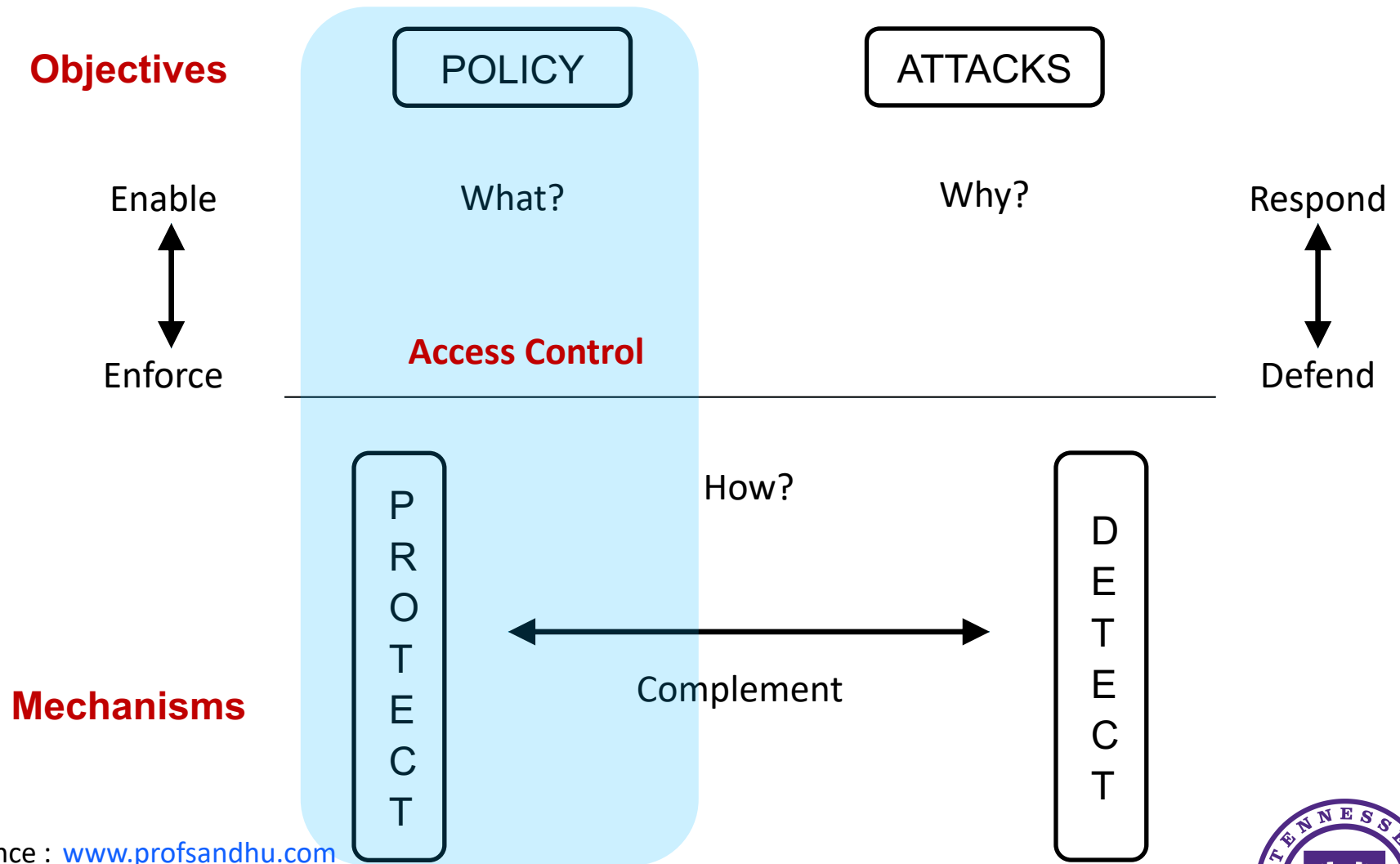
Mechanisms



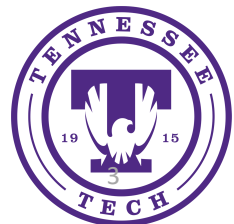
Reference : www.profsandhu.com



Cyber Security Landscape

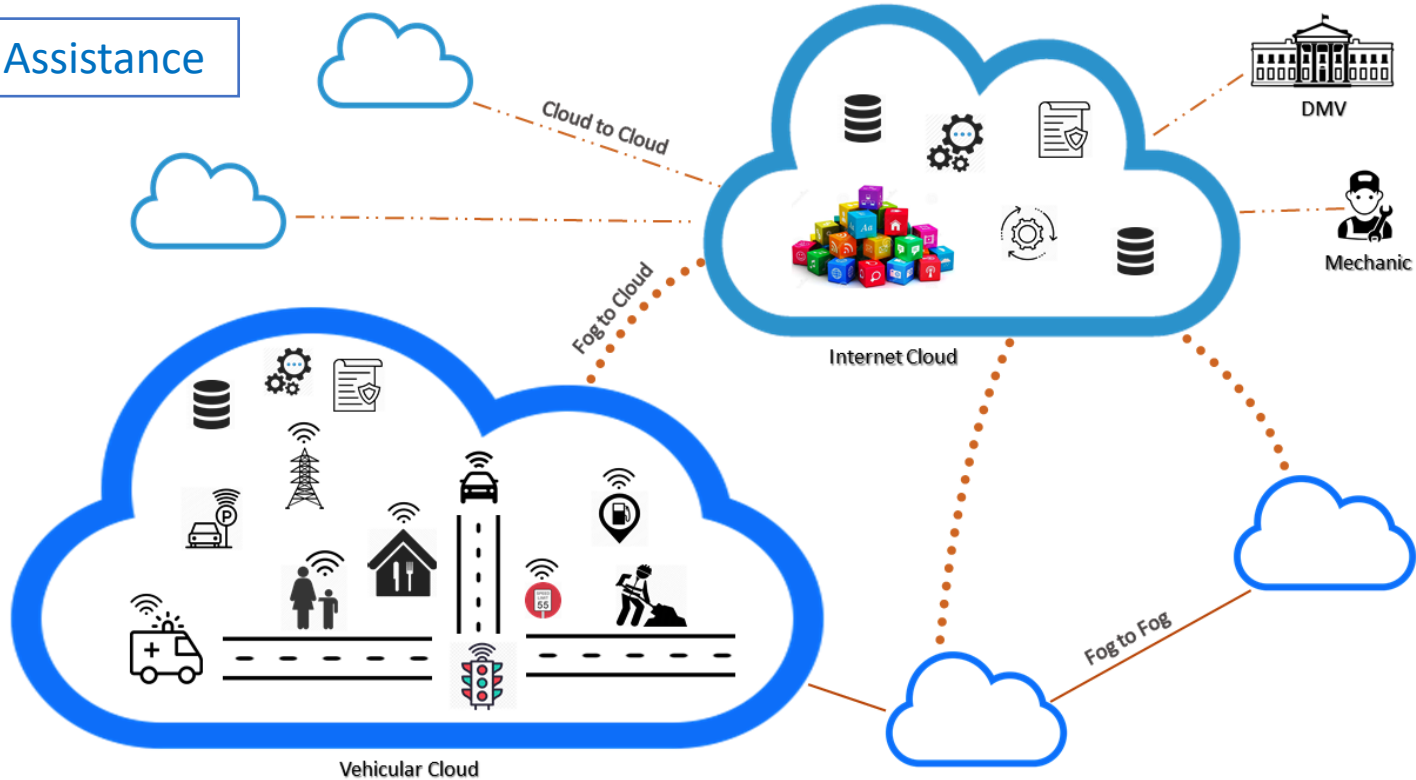


Reference : www.profsandhu.com



Smart Cars Ecosystem

Safety and Assistance

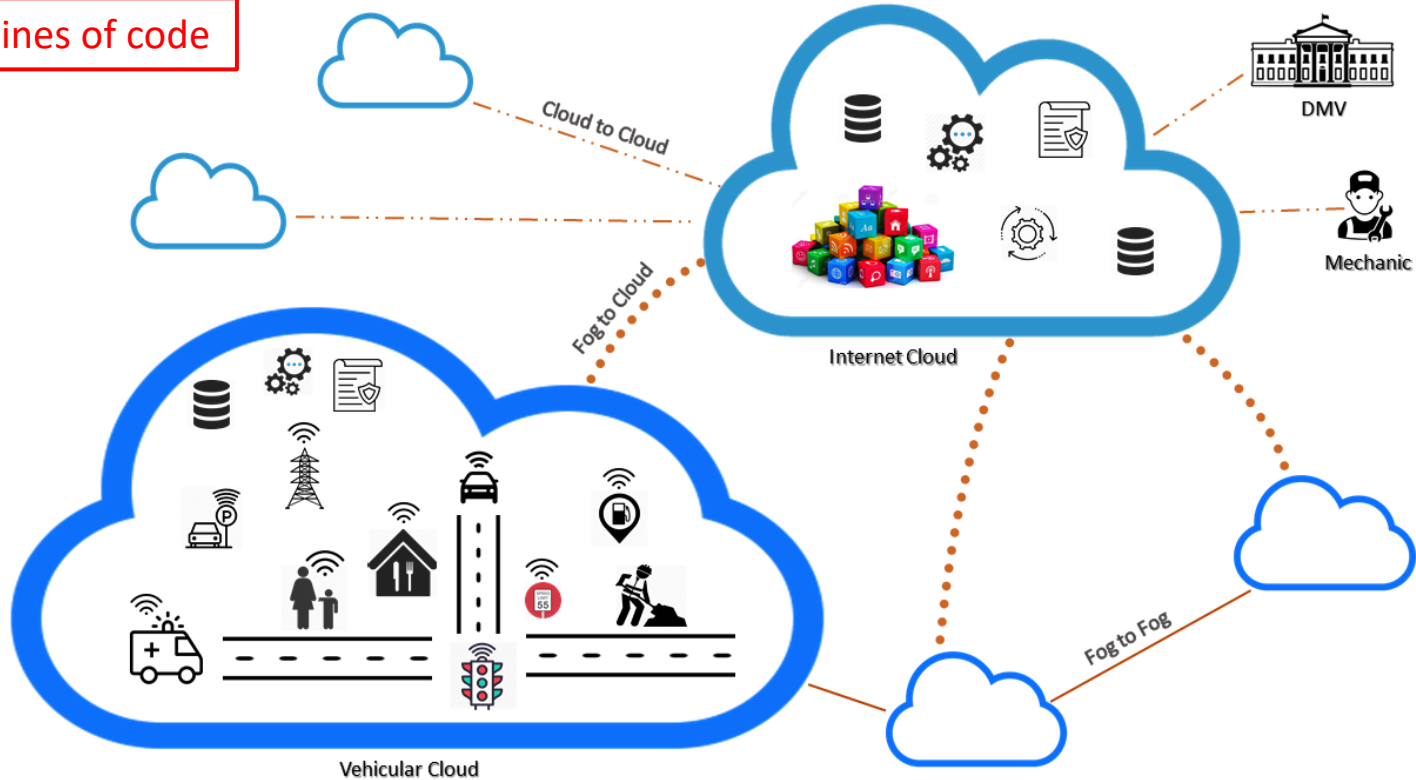


Information and Entertainment

High Mobility, Location Centric
Time Sensitive, Dynamic Pairing
Multiple Fog/Cloud Infrastructures

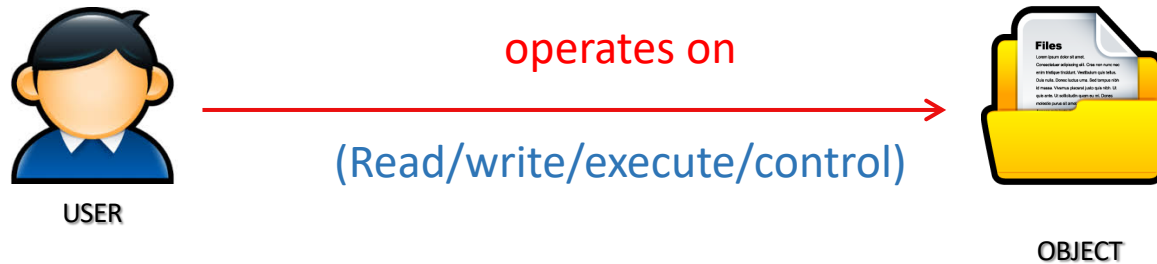
No More Isolated.!

100 million lines of code



Software Reliance , Broad Attack Surface, Untrusted Entities

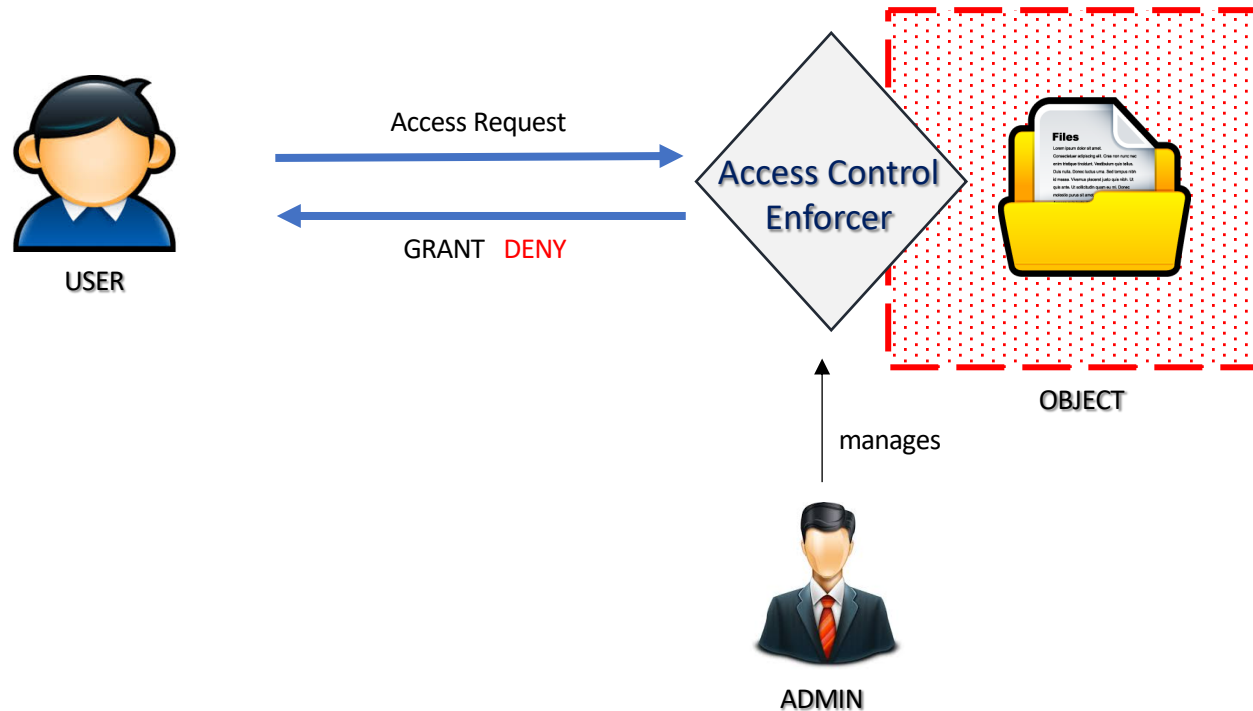
The Perfect World.!



I **TRUST** my users.
Everything is Secure. !!

Confidentiality
Integrity
Availability

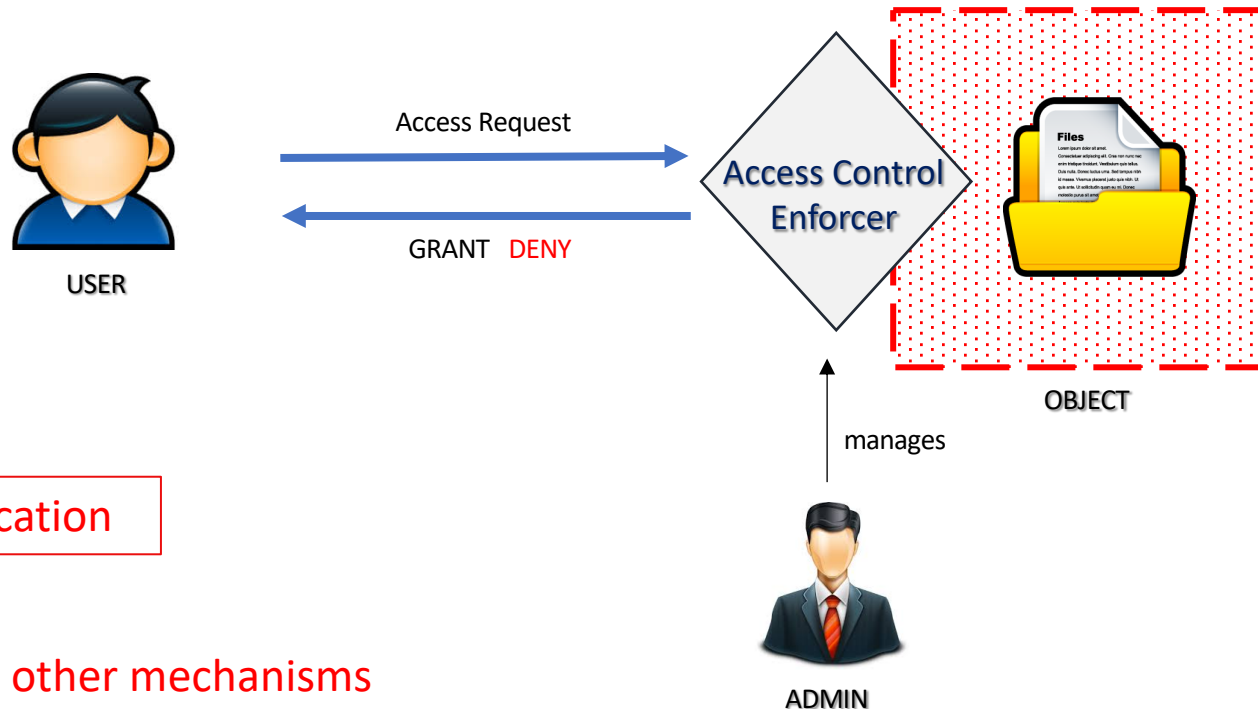
Access Control Mechanisms



A user **[U]** is allowed to perform an operation **[OP]** on an object **[OB]** if security policy **[P]** is satisfied.

Access Control Mechanisms

PROTECTION



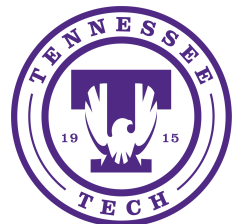
Post Authentication

Complements other mechanisms

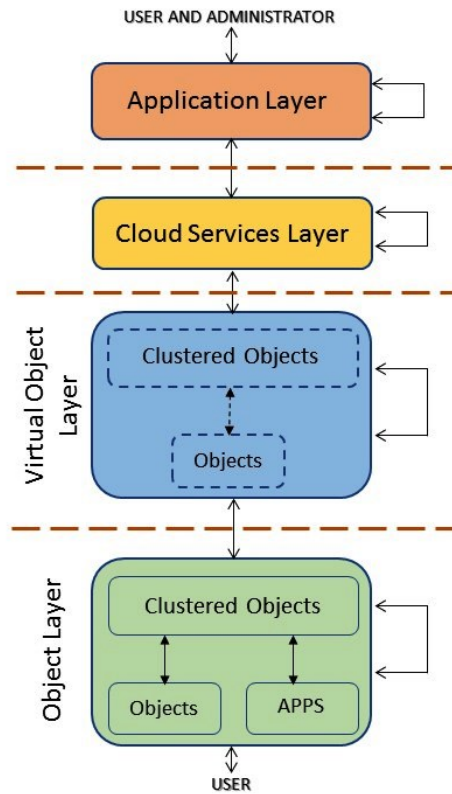
A user **[U]** is allowed to perform an operation **[OP]** on an object **[OB]** if security policy **[P]** is satisfied.

Attribute Based Access Control

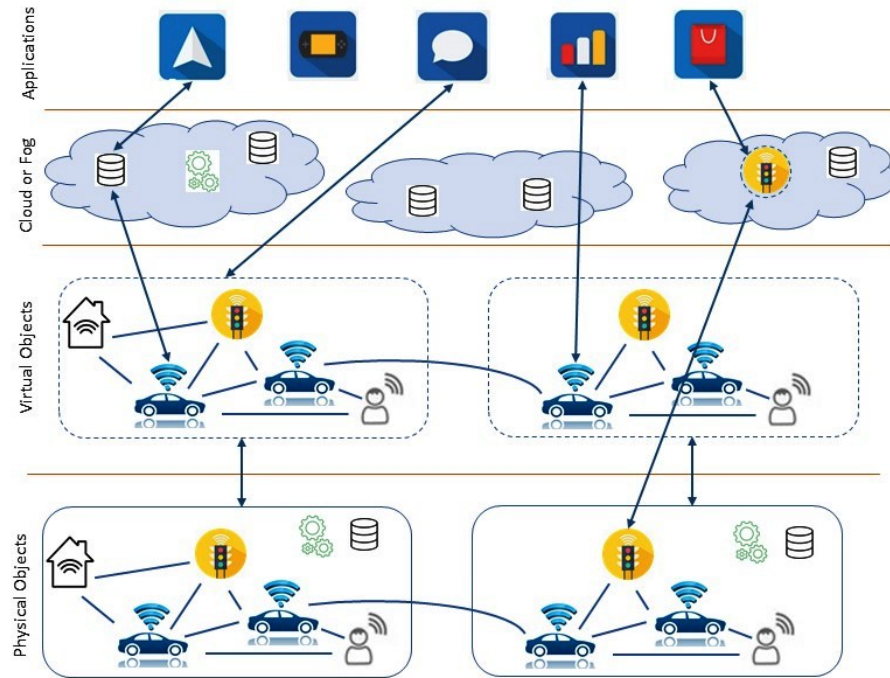
- Three Dominant Models: DAC, MAC and RBAC.
 - ABAC: Decision based on the attributes of entities
 - Attributes are name value pair: age (Alice) → 29
 - Core entities in ABAC include:
 - ❖ Users
 - ❖ Objects
 - ❖ Environment or Context
 - ❖ Operations
- } Attributes
- Authorization Policies: determine rights just in time
 - ❖ retrieve attributes of relevant entities in request
 - Enhance flexibility and fine grained access control
 - NIST Guidelines to ABAC



Extended Access Control Oriented Architecture

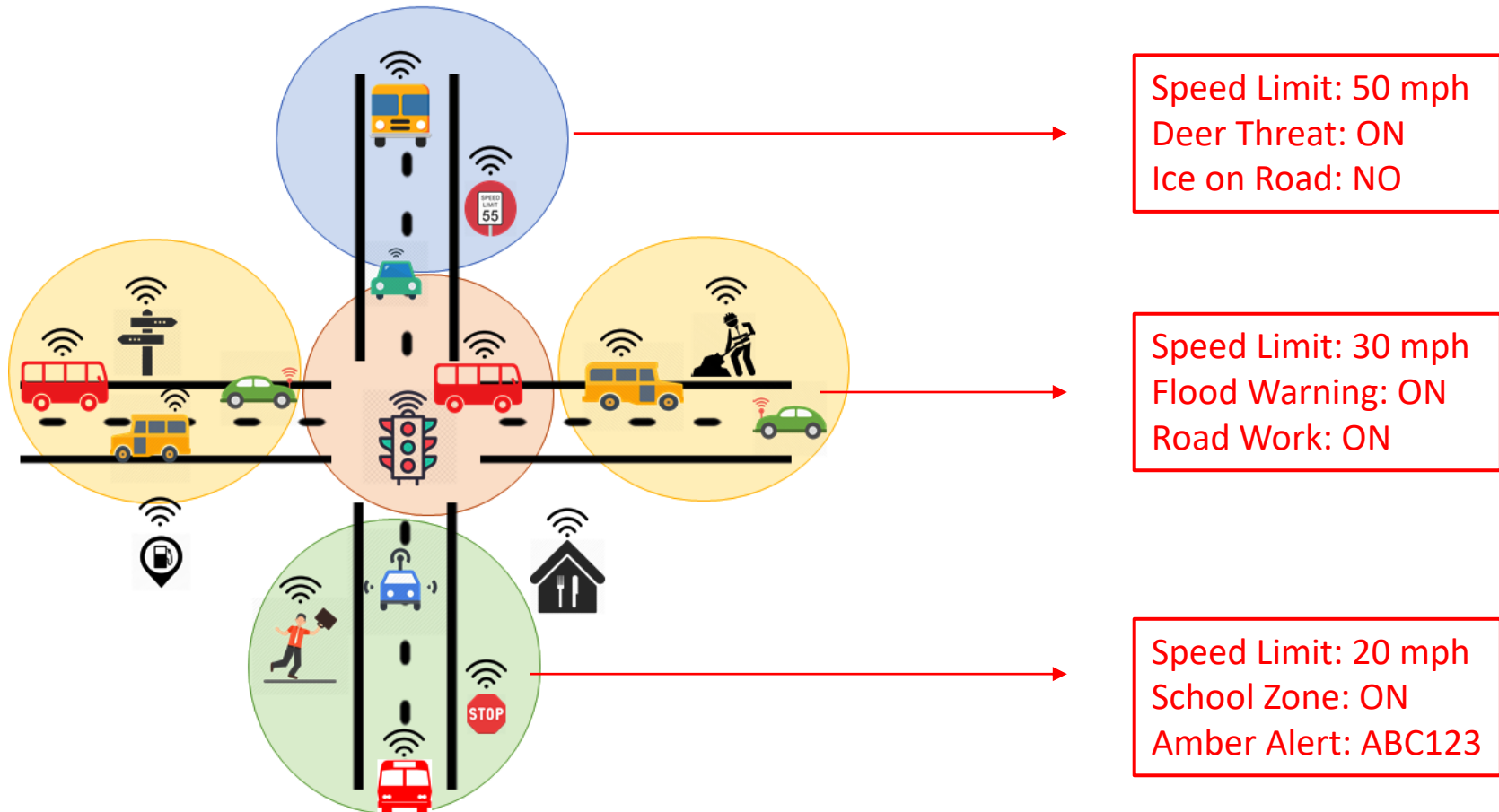


E-ACO architecture



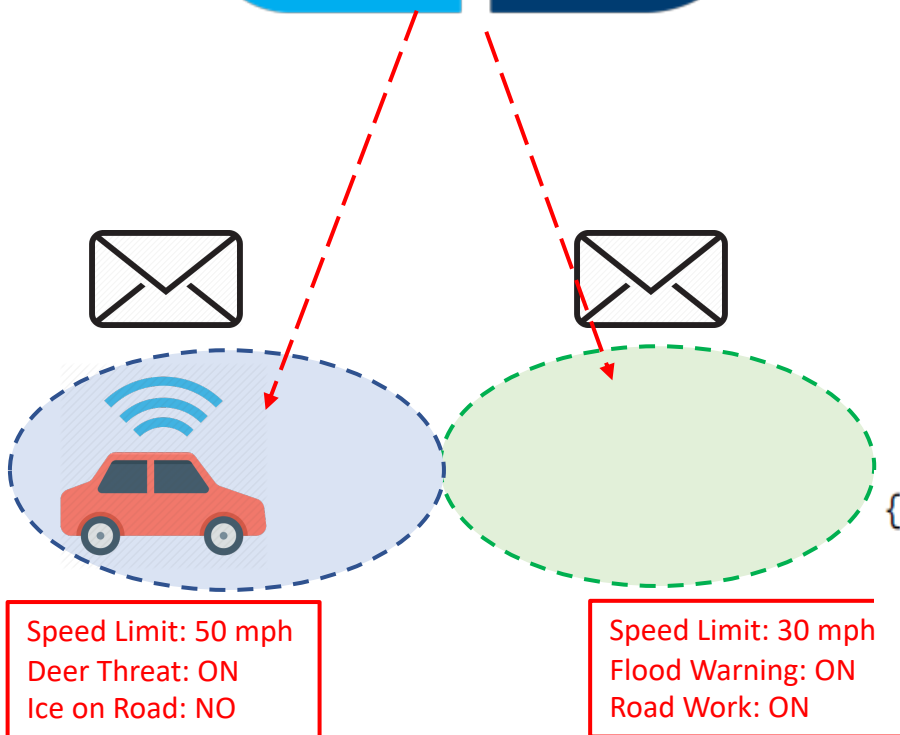
Vehicular IoT components in architecture

Attributes and Alerts



Vehicle moves and are assigned to different groups and inherits their attributes/alerts.

Using Location Groups



Administrative Questions:

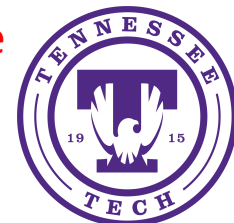
- How the attributes or alerts of groups are updated?
- How are moving entities assigned to groups?
- How groups hierarchy is created?

Operational Questions:

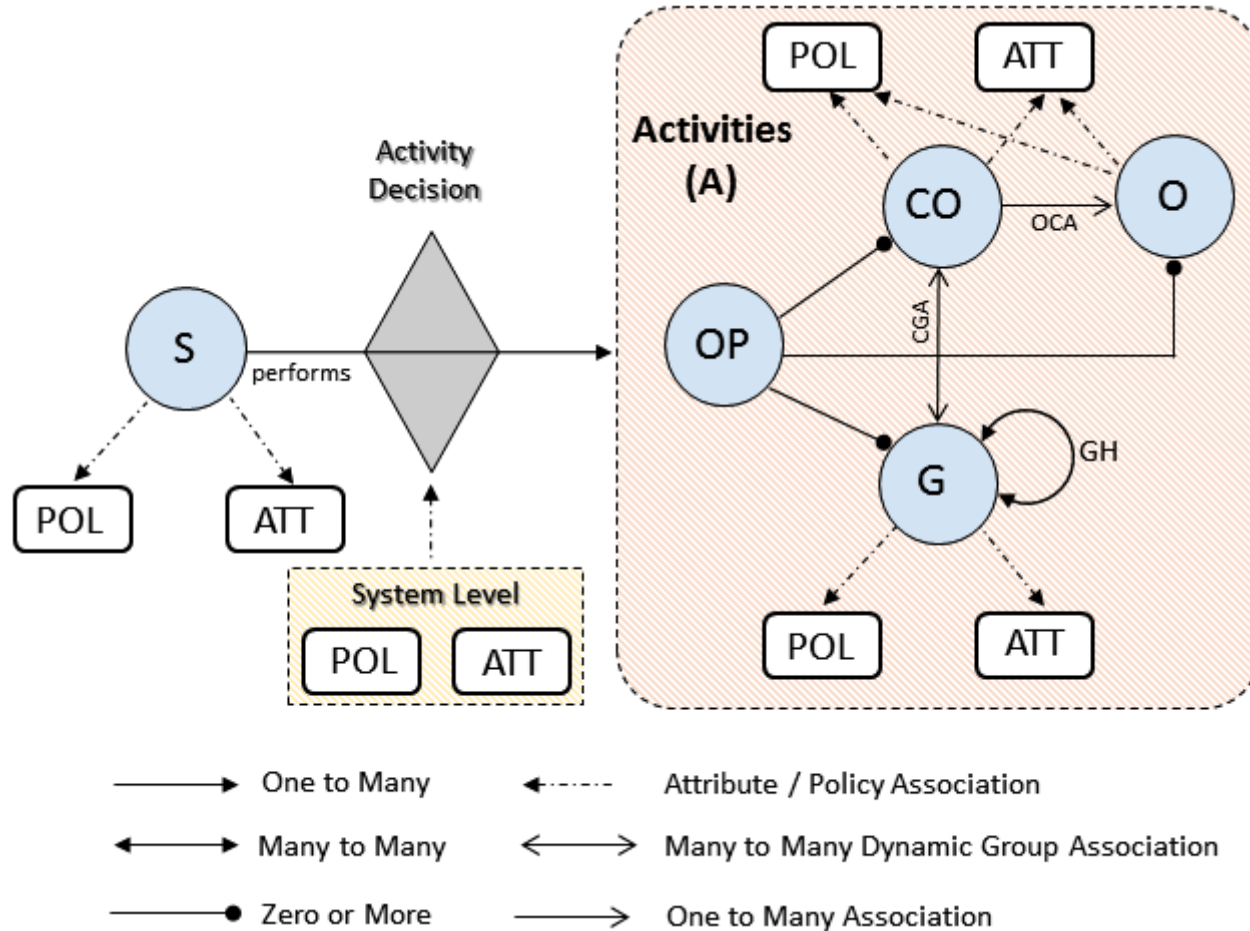
- How attributes and groups are used to provide security?
- How user privacy preferences are considered?

```
{"state": {"reported": {"Latitude": "29.4769353",  
                        "Longitude": "-98.5018237"}}}
```

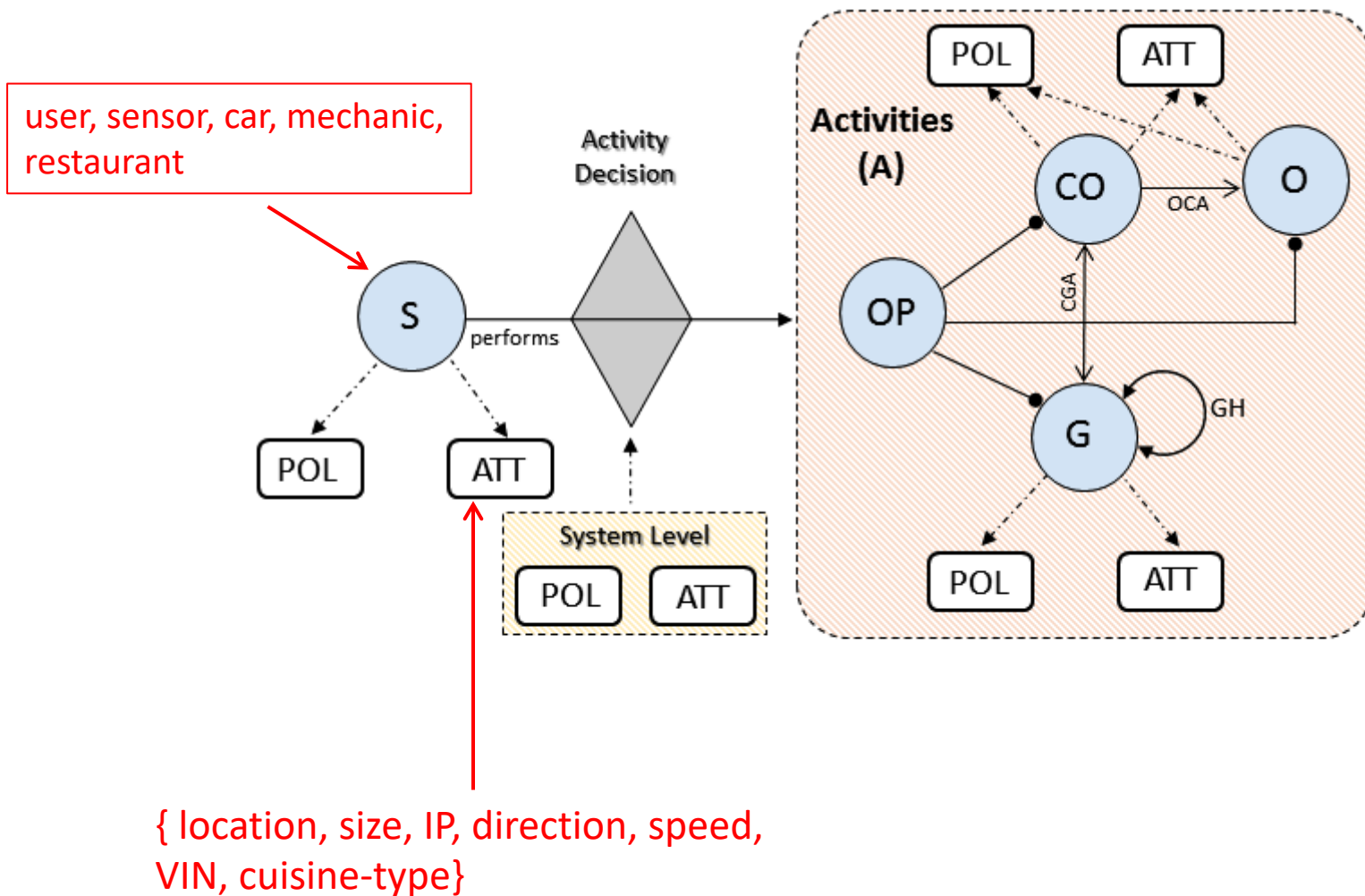
Reported MQTT message



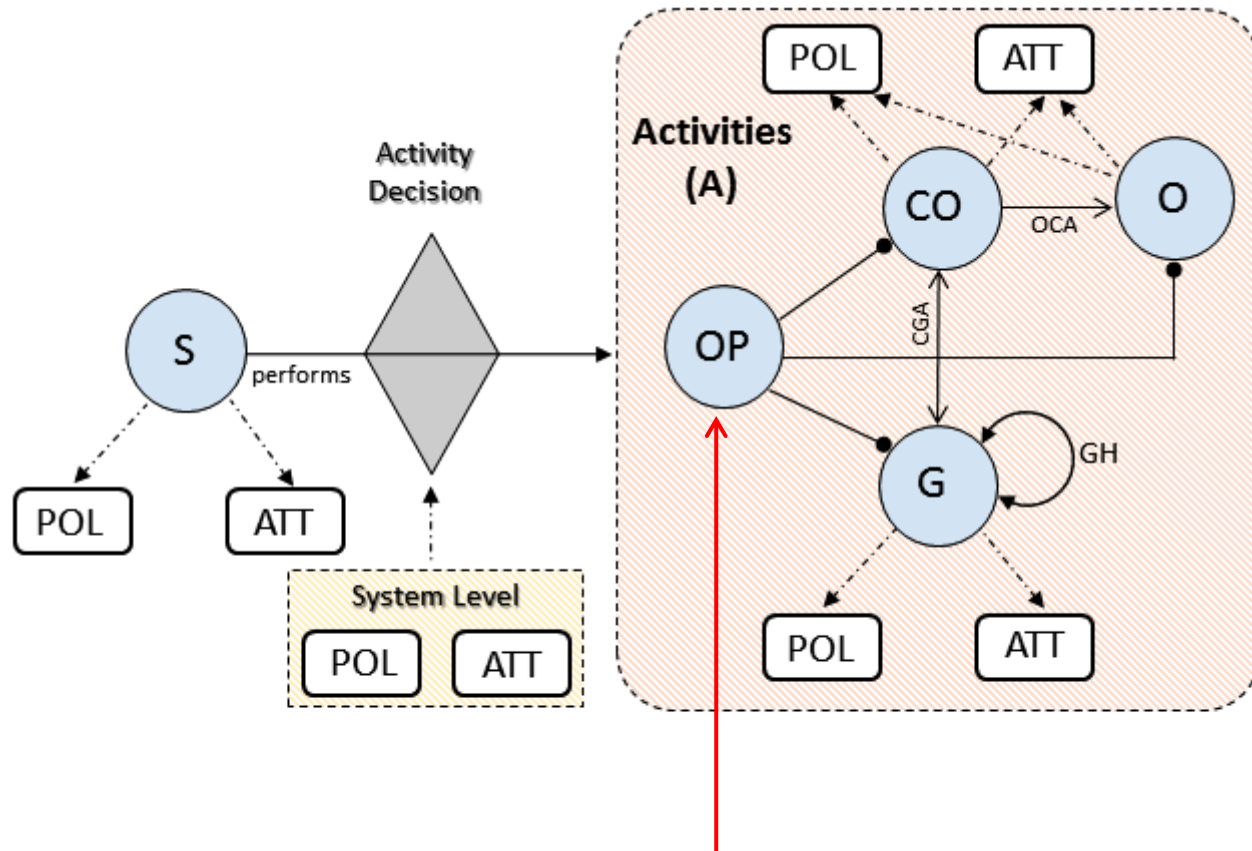
CV-ABAC_G Model



Model Components



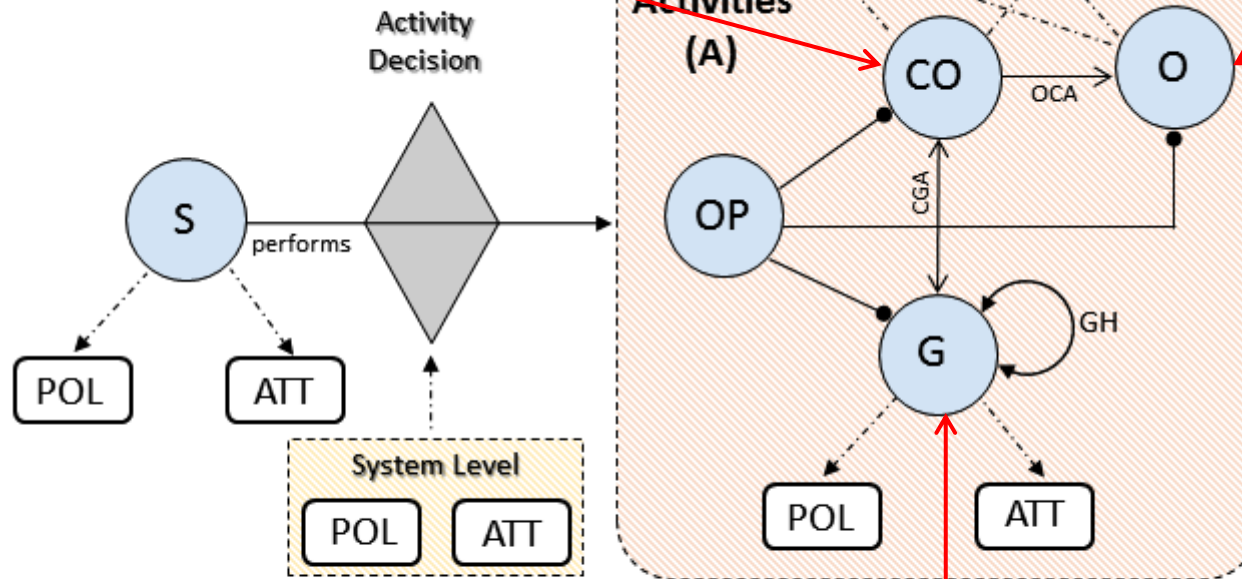
Model Components



{ read, write, control, notify, administrative actions }

Model Components

Cars, traffic lights, smart-devices



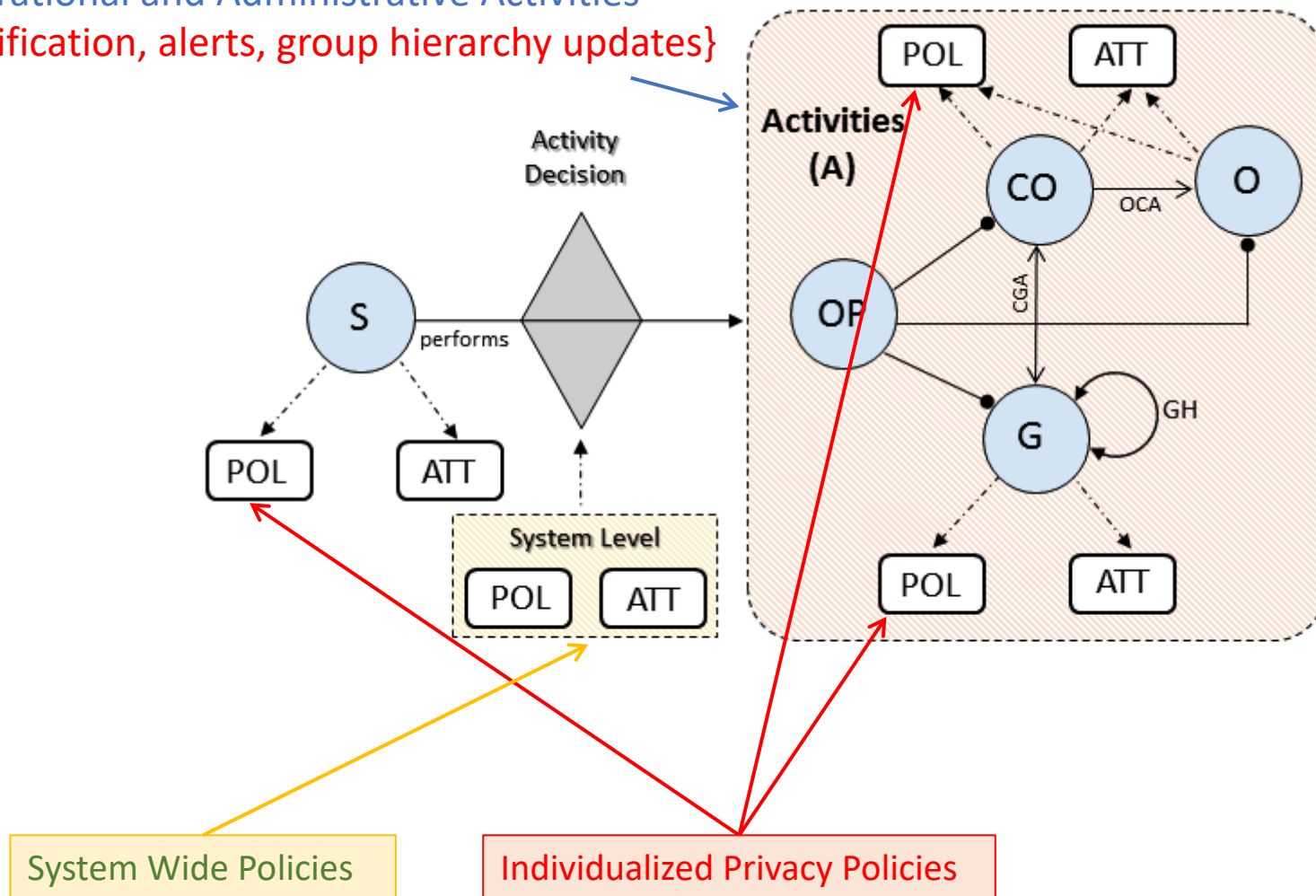
Sensor, ECU, on-board apps

Location groups, service-specific, vehicle-type

Model Components

Operational and Administrative Activities

{notification, alerts, group hierarchy updates}



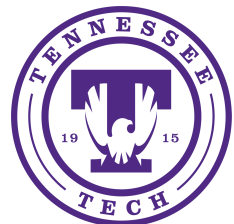
Formal Specification

Basic Sets and Functions

- S, CO, O, G, OP are finite sets of sources, clustered objects, objects, groups and operations respectively [blue circles in Figure 4].
- A is a finite set of activities which can be performed in system.
- ATT is a finite set of attributes associated with S, CO, O, G and system-wide. **Attribute Function**
- For each attribute att in ATT, Range(att) is a finite set of atomic values.
- attType: ATT = {set, atomic}, defines attributes to be set or atomic valued. **Attribute Type**
- Each attribute att in ATT maps entities in S, CO, O, G to attribute values. Formally,
$$\text{att} : S \cup CO \cup O \cup G \cup \{\text{system-wide}\} \rightarrow \begin{cases} \text{Range}(\text{att}) \cup \{\perp\} & \text{if attType(att) = atomic} \\ 2^{\text{Range}(\text{att})} & \text{if attType(att) = set} \end{cases}$$
- POL is a finite set of authorization policies associated with individual S, CO, O, G.
- directG : CO \rightarrow G, mapping each clustered object to a system group, equivalently CGA \subseteq CO \times G.
- parentCO : O \rightarrow CO, mapping each object to a clustered object, equivalently OCA \subseteq O \times CO.
- GH \subseteq G \times G, a partial order relation \geq_g on G. Equivalently, parentG : G \rightarrow 2^G, mapping group to a set of parent groups in hierarchy.

Group Hierarchy

Attribute Mapping



Formal Specification

Effective Attributes of Groups, Clustered Objects and Objects (Derived Functions)

– For each attribute att in ATT such that $attType(att) = \text{set}$:

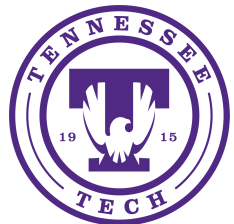
- $effG_{att} : G \rightarrow 2^{\text{Range}(att)}$, defined as $effG_{att}(g_i) = att(g_i) \cup \left(\bigcup_{g \in \{g_j | g_i \geq_g g_j\}} effG_{att}(g) \right)$.
- $effCO_{att} : CO \rightarrow 2^{\text{Range}(att)}$, defined as $effCO_{att}(co) = att(co) \cup effG_{att}(\text{directG}(co))$.
- $effO_{att} : O \rightarrow 2^{\text{Range}(att)}$, defined as $effO_{att}(o) = att(o) \cup effCO_{att}(\text{parentCO}(o))$.

– For each attribute att in ATT such that $attType(att) = \text{atomic}$:

- $effG_{att} : G \rightarrow \text{Range}(att) \cup \{\perp\}$, defined as $effG_{att}(g_i) = \begin{cases} att(g_i) & \text{if } \forall g' \in \text{parentG}(g_i). effG_{att}(g') = \perp \\ effG_{att}(g') & \text{if } \exists \text{parentG}(g_i). effG_{att}(\text{parentG}(g_i)) \neq \perp \text{ then select} \\ & \text{parent } g' \text{ with } effG_{att}(g') \neq \perp \text{ updated most recently.} \end{cases}$
- $effCO_{att} : CO \rightarrow \text{Range}(att) \cup \{\perp\}$, defined as $effCO_{att}(co) = \begin{cases} att(co) & \text{if } effG_{att}(\text{directG}(co)) = \perp \\ effG_{att}(\text{directG}(co)) & \text{otherwise} \end{cases}$
- $effO_{att} : O \rightarrow \text{Range}(att) \cup \{\perp\}$, defined as $effO_{att}(o) = \begin{cases} att(o) & \text{if } effCO_{att}(\text{parentCO}(o)) = \perp \\ effCO_{att}(\text{parentCO}(o)) & \text{otherwise} \end{cases}$

Attributes more Dynamic

Attributes Inheritance



Policy Language

Authorization Functions (Policies)

– Authorization Function: For each $op \in OP$, $Auth_{op}(s : S, ob : CO \cup O \cup G)$ is a propositional logic formula returning true or false, which is defined using the following policy language:

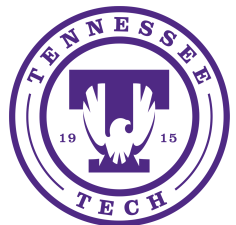
- $\alpha ::= \alpha \wedge \alpha \mid \alpha \vee \alpha \mid (\alpha) \mid \neg \alpha \mid \exists x \in \text{set}.\alpha \mid \forall x \in \text{set}.\alpha \mid \text{set} \Delta \text{set} \mid \text{atomic} \in \text{set} \mid \text{atomic} \notin \text{set}$
- $\Delta ::= \subset \mid \subseteq \mid \not\subseteq \mid \cap \mid \cup$
- $\text{set} ::= \text{eff}_{att}(i) \mid \text{att}(i)$ for $att \in ATT, i \in S \cup CO \cup O \cup G \cup \{\text{system-wide}\}, \text{attType}(att) = \text{set}$
- $\text{atomic} ::= \text{eff}_{att}(i) \mid \text{att}(i) \mid \text{value}$ for $att \in ATT, i \in S \cup CO \cup O \cup G \cup \{\text{system-wide}\}, \text{attType}(att) = \text{atomic}$

❖ Administrators in the police department can send alert to location-groups in city limits.

$Auth_{\text{alert}}(u:U, g:G) :: \text{dept}(u) = \text{Police} \wedge \text{parent-city}(g) = \text{Austin} \wedge$
 $\text{Austin} \in \text{jursidiction}(u).$

❖ Only mechanic in the technician department from Toyota-X dealership must be able to read sensor in Camry LE. Further, this operation must be done between time 9 am to 6 pm.

$Auth_{\text{read}}(u:U, co:CO) :: \text{role}(u) = \text{Technician} \wedge \text{employer}(u) = \text{Toyota-X} \wedge$
 $\text{make}(co) = \text{Toyota} \wedge \text{model}(co) = \text{Camry LE} \wedge$
 $\text{operation_time}(u) \in \{9\text{am}, 10, 11 \dots 6\text{pm}\}$



Activity Authorization Decision

Authorization Decision

– A source $s \in S$ is allowed to perform an activity $a \in A$, stated as $\text{Authorization}(a : A, s : S)$, if the required policies needed to allow the activity are included and evaluated to make final decision. These multi-layer policies must be evaluated for individual operations ($op_i \in OP$) to be performed by source $s \in S$ on relevant objects ($x_i \in CO \cup O \cup G$)

Formally, $\text{Authorization}(a : A, s : S) \Rightarrow \text{Auth}_{op_1}(s : S, x_1), \text{Auth}_{op_2}(s : S, x_2), \dots, \text{Auth}_{op_n}(s : S, x_n)$

Evaluate all relevant policies to make a decision

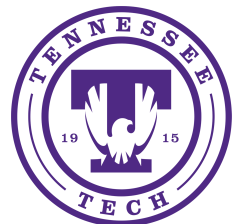
A restaurant in group A must be allowed to send notifications to all vehicles in location group A and group B.

I only want notifications from Cheesecake factory.

System defined

DECISION

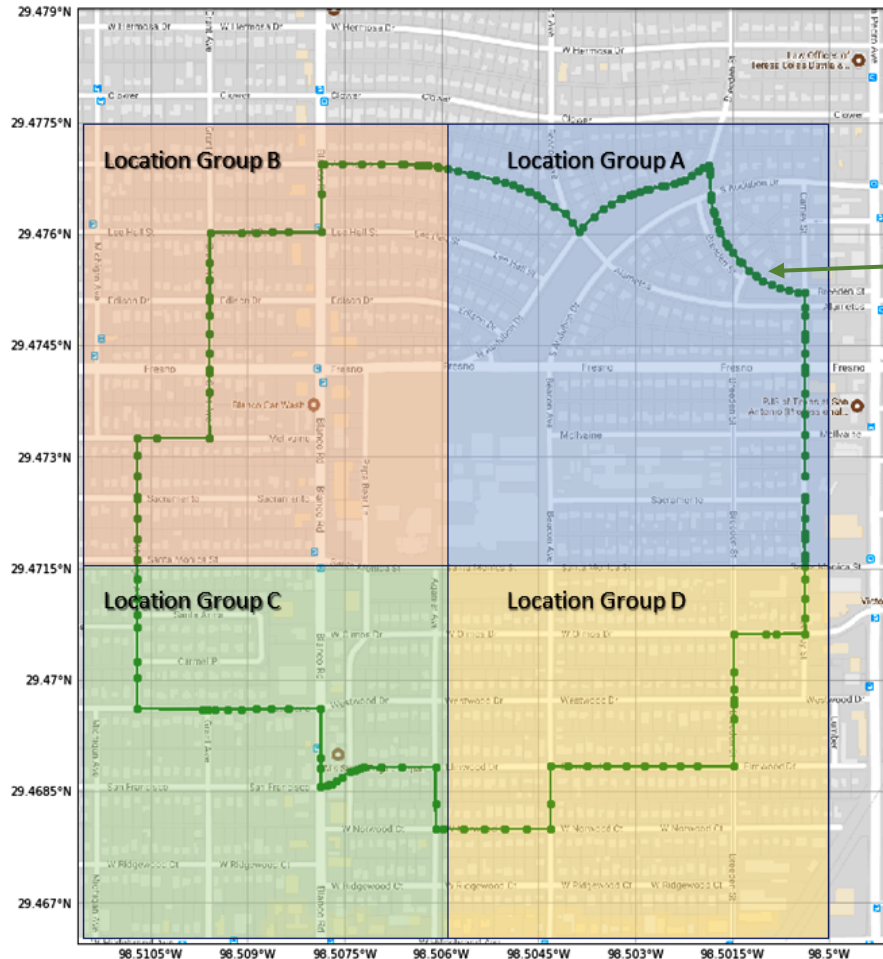
User Preference



Implementation in Amazon Web Services (AWS)



Vehicles and Groups



4 Location Groups
(static demarcation)

Vehicles movement
(coordinates generated
using Google API)

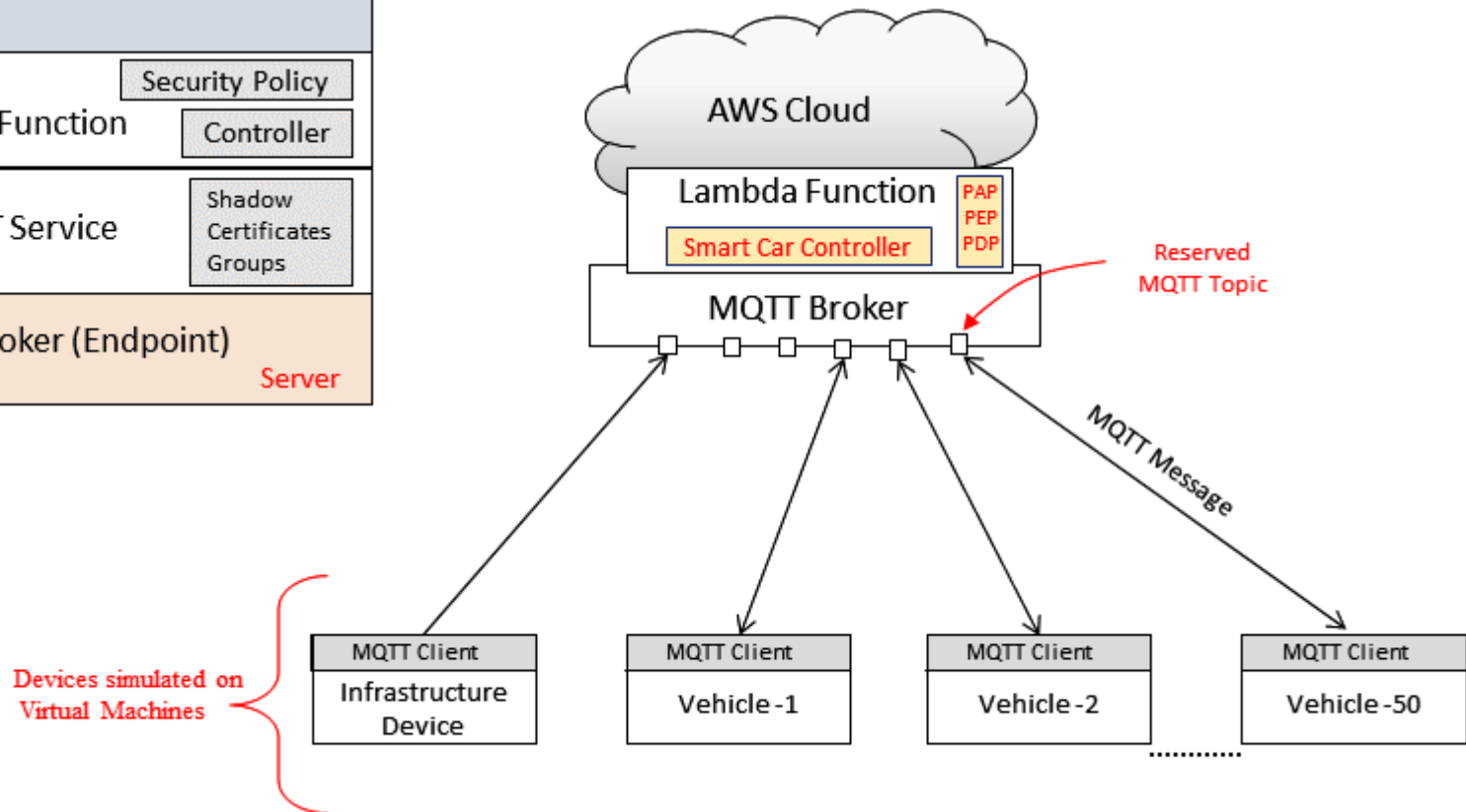
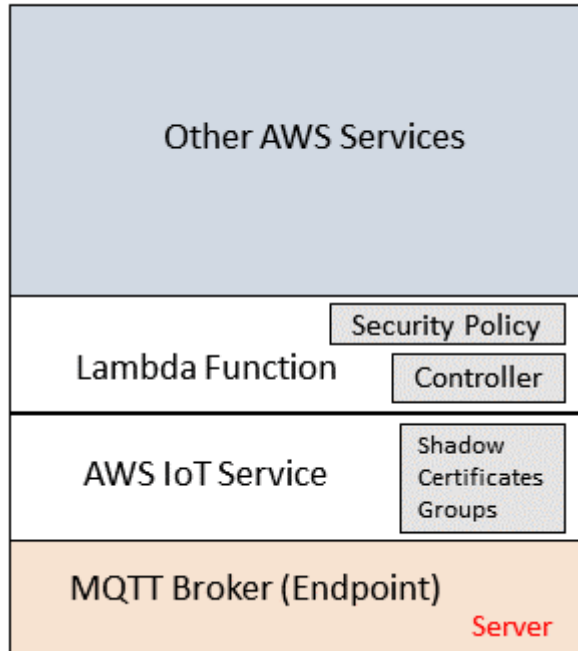
```
('Received new coordinates from:', 'Vehicle-1')
Sun May 27 02:56:30 2018
Location A
  Car-A : [u'Vehicle-1', u'Vehicle-2']
  Bus-A : []
Location B
  Car-B : []
  Bus-B : [u'Vehicle-6']
Location C
  Car-C : [u'Vehicle-3', u'Vehicle-4']
  Bus-C : []
Location D
  Car-D : []
  Bus-D : [u'Vehicle-5']
```

Snapshot (table keeps changing)

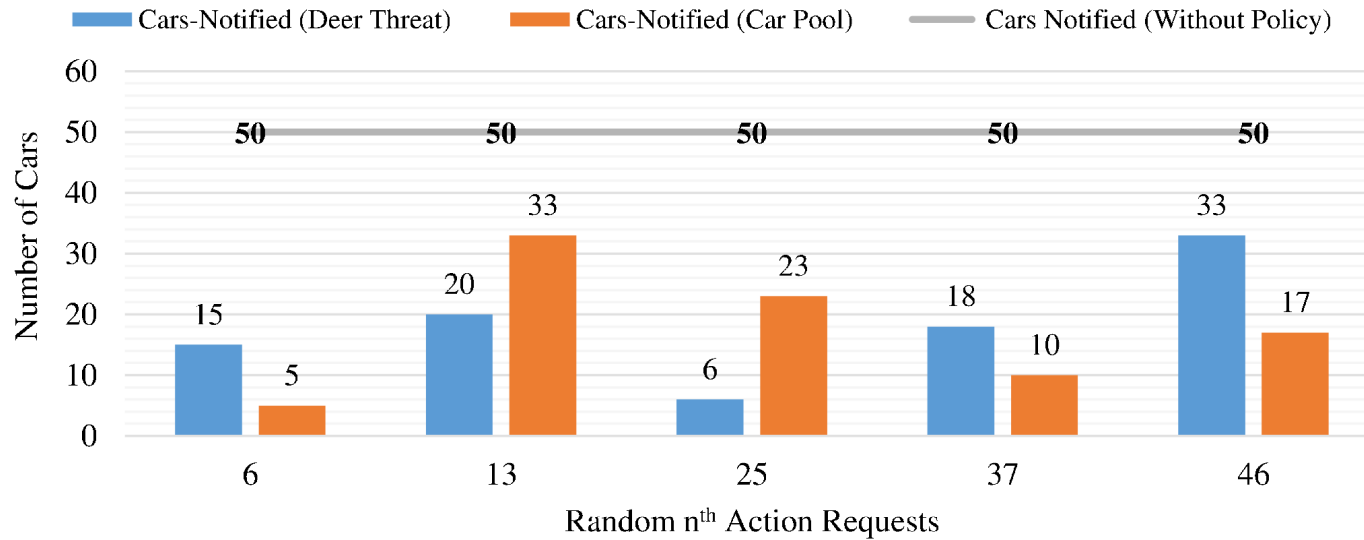


AWS Architecture

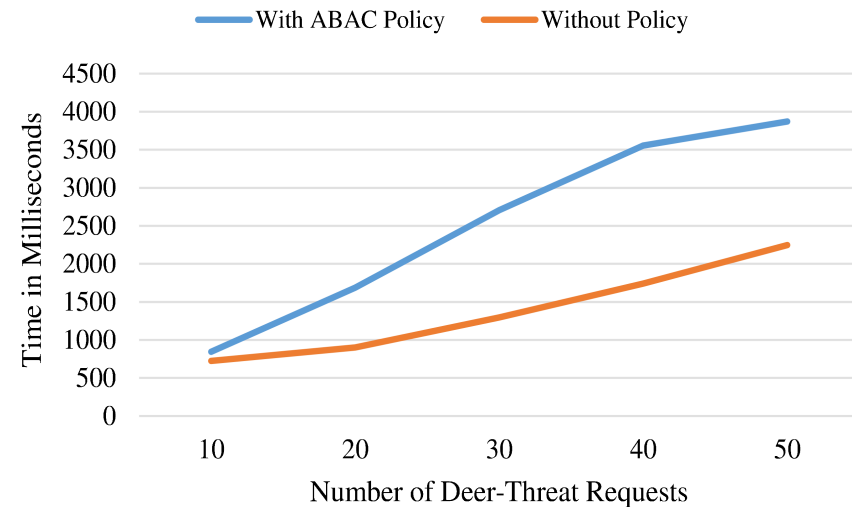
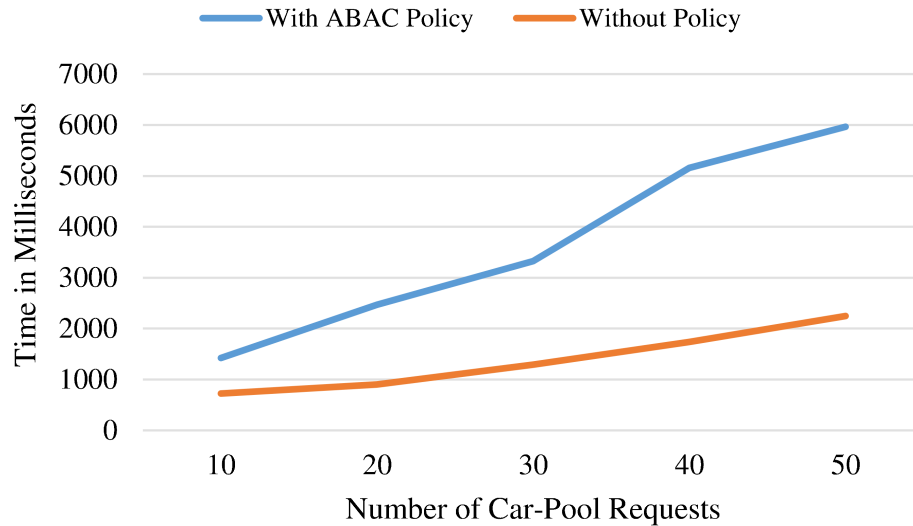
AWS Cloud Components



Performance Metrics



Performance Metrics



Let's Talk ..!!

Questions, Comments or Concerns

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