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Role-Based Administration of Role-Based Smart Home IoT

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Outline

Introduction and Background

- IoT Access Control Requirements
- Role-Base Access Control (RBAC)

RBAC Administrative Model for Smart Home IoT

- Operational Model for Smart Home IoT
  - EGRBAC Model Introduction
- Administrative Model for Smart Home IoT
  - RBAC Administrative Policy Model
  - Administrative Use Case
  - Proposed Model's Properties and Restrictions

Conclusion and Future Work

- What could be done?

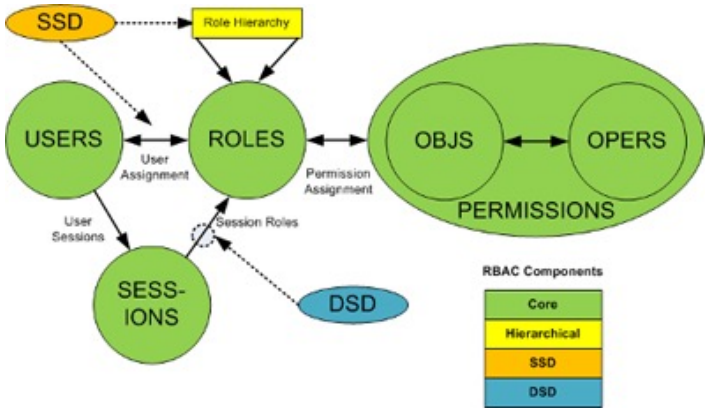
Internet of Things (IoT)

IoT Access Control

Policy Specification	Granularity	●	●	●	●	●
	Context Awareness	●	●	●	●	●
Policy Management	Handling the complexity of Environment	○	●	●	◑	●
	Usability	●	○	○	●	○
	Multi-domain Administration	○	●	●	◑	●
Policy Enforcement	Minimum user involvement	◑	●	●	●	●
	Light-weight	◑	◑	◑	●	●
	Reliability and Availability	●	●	●	●	●

Role-Based Access Control (RBAC)

- RBAC mediate permission assignment to users via the concept of a role.
- RBAC virtues include its policy neutrality, adherence to least privilege principle, and ease of management.
- Administration is facilitated by assigning different users to define roles or making changes to existing role sets of the system.



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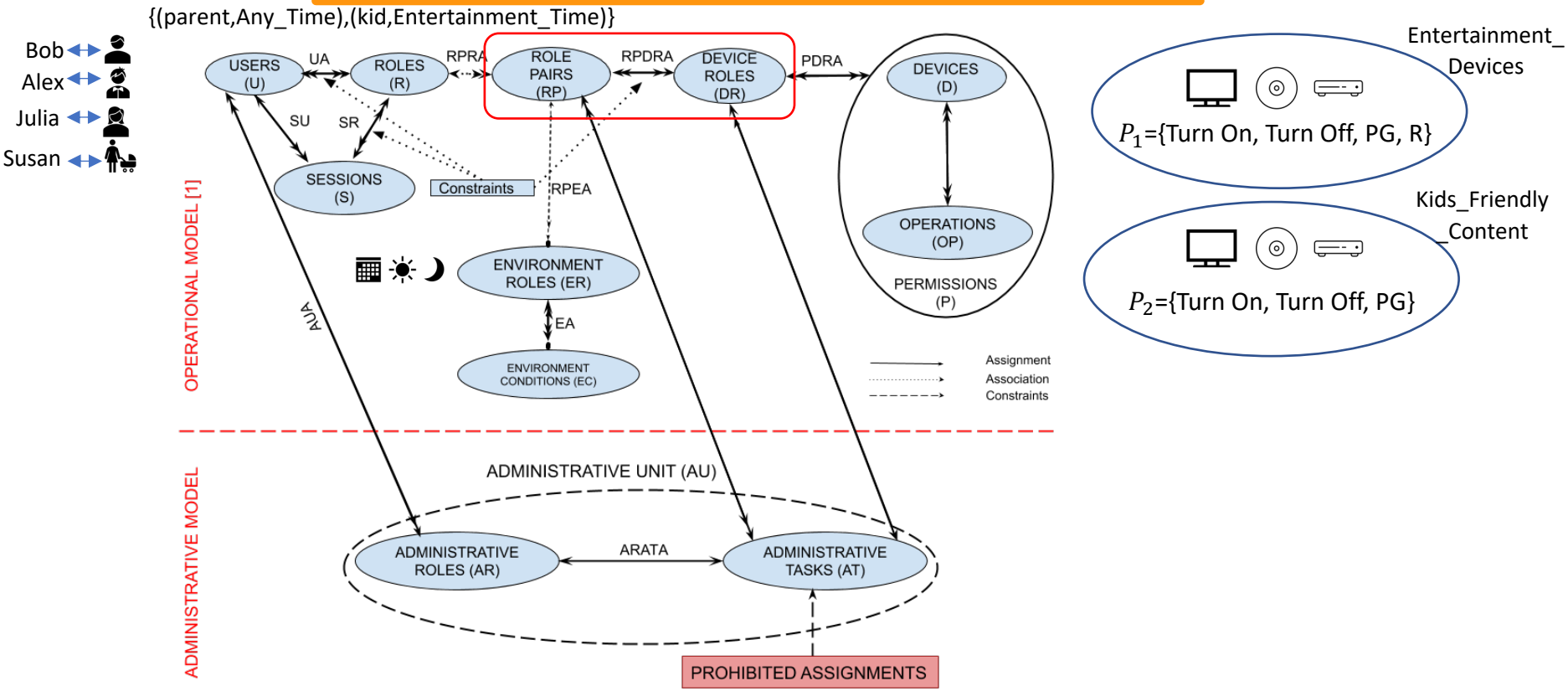
Operational Model for Smart Home IoT

- Many operational models have been proposed for Smart Home IoT.
- EGRBAC (Extended Generalized RBAC) is a generalized RBAC model for user-to-device operational access [Ameer et al., 2020]
  - Provides granularity by defining Device Roles (DR)
    - It is permission-centric, instead of device-centric
  - Capture the environmental conditions through Environmental Roles (ER)
  - Contextuality has been provided via Role Pair (RP) definition

Basic Administrative Model



- Administrative Unit (AU) is the core component of decentralization.
- Each AU contains a unique specific Administrative Role (AR) and a set of Administrative Tasks (AT).
- Authorization is scoped as a set of administrative tasks defined to manage corresponding assignments in an operational model.

RBAC Administrative Model for Smart Home

- Our model addresses the administration of EGRBAC.
- Our model is decentralized:
  - Avoid single point of failure
  - Improve users' privacy
- Potential changes to the dynamic environment of smart home include:
  - Add a new user
  - Add a new device ☑
  - Modification of current assignments in the model ☑

Smart Home Use Case

au_1 = Entertainment_Management

ar_1 = Entertainment_Manager

at_1 = { DR={ENTERTAINMENT_DEVICES, KIDS_FRIENDLY_CONTENT} RP={(KID, ENTERTAINMENT_TIME), (PARENT,ANY_TIME), (GUEST, ANY_TIME)} }

au_2 = Adult_Management

ar_2 = Adult_Manager

at_2 = { DR={ADULT_CONTROLLED} RP={(PARENT,ANY_TIME), (BABY_SITTER, ANY_TIME)} }

((KID,ENTERTAINMENT_TIME), ENTERTAINMENT_DEVICES)

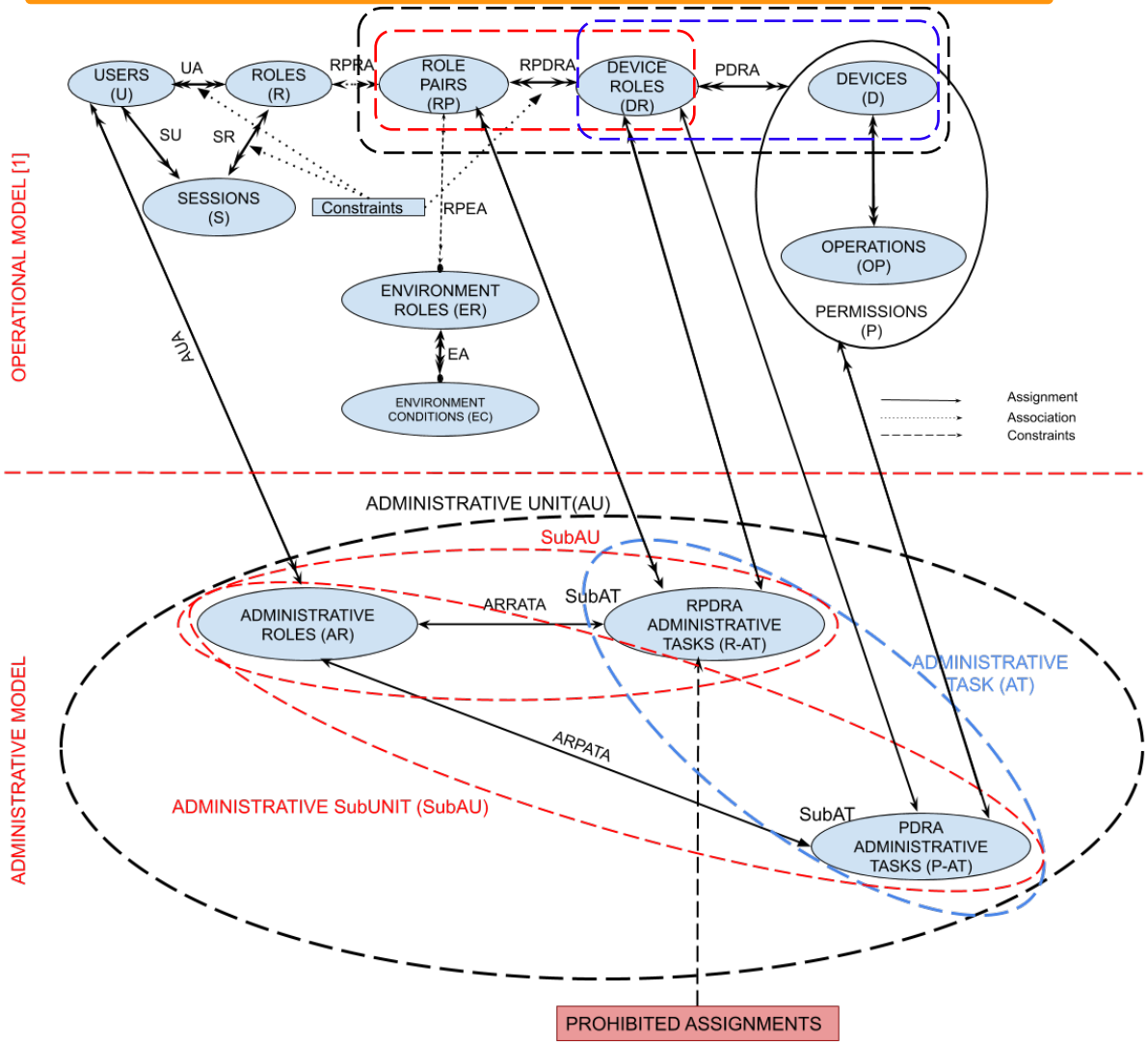
Prohibited Assignments

au_3 = Ownership_Control

ar_3 = Home_Owner

at_3 = { DR={OWNER_CONTROLLED} RP={(PARENT,ANY_TIME)} }

Extended Administrative Model



Extended Administrative Model Formalization

Core Components

– $AUser \subset U$ is a set of administrator users.

– AR is a set of administrative roles, authorized to manage a specified subset of RPDRA.

– $AUA \subset AUser \times AR$ is a many to many administrator user to administrative role assignment.

– $AU = \cup_{\forall i} SubAU_i$,is a set of administrative sub-units (SubAU).

– AT is a set of administrative sub-tasks (SubAT), i.e. $AT = P-AT \cup R-AT$.

– $R-AT \subseteq (2^{RP} \times 2^{DR}) \backslash ProhibitedAssignment$ is a set of administrative tasks related to RPDRA assignment, which contains all pairs of cross product of a subset of RP, and a a subset of DR, but a set of Prohibited Assignments has to be excluded.

– $P-AT \subseteq (2^{P} \times 2^{DR})$ is a set of administrative tasks related to PDRA assignment.

– $SubAU \subset AR \times \{R-AT, P-AT\}$ is a administrative sub-unit.

Administrative Constraint

– $ProhibitedAssignment$ is a set of prohibited (rp, dr) pairs each of which is a member of possible pairs of assignment but specified to be forbidden to be added to RPDRA by design, ($Constratints \subset RP \times DR$).

Administrative Authorization

– $ARRATA \subseteq AR \times R-AT$, is a one to one AR to R-AT assignment determining the scope of administrative control for a given AR on RPDRA.

– $ARPATA \subseteq AR \times P-AT$, is a one to one AR to P-AT assignment determining the scope of administrative control for a given AR on PDRA.

– $ARAUA \subseteq AR \times AU$ is a one to one AR to AU assignment, determines which AU is under control of a given AR.

Derived Administrative Relations

– $AR_{at \in SubAT} \subset SubAT \in AT \times AR : AR_{AT}(at) = ar \in AR : at \in ARRATA(ar) \vee at \in ARPATA(ar)$: many to one administrative subtask to administrative role function which determines which AR can manage this AT.

– $RolePair_{at \in AT} \subseteq 2^{RP}$ determines which role pairs are included in a given administrative task.

– $DeviceRole_{at \in AT} \subseteq 2^{DR}$ discovers the device roles which are included in a given administrative task.

– $InclusiveTask((st, dr)) \subseteq (\{st \in RP\} \vee \{st \in P\}, dr \in DR) \times \{AT \cup FALSE\}$ determines the association of a (st, dr) to an administrative task if this pair is currently defined as a member of that administrative task, if no inclusive administrative task found, it returns FALSE.

Authorization Functions

– $\textsc{assignRPDR}(auser \in AUser, ar \in AR, rp \in RP, dr \in DR) \equiv$
$((\text{at} = \text{InclusiveTask(rp,dr)} \wedge ar = AR_{at} \wedge (rp, dr) \notin RPDRA)) \Rightarrow RPDRA' = RPDRA \cup (rp, dr)$

– $\textsc{revokeRPDR}(auser \in AUser, ar \in AR, rp \in RP, dr \in DR) \equiv$
$((\text{at} = \text{InclusiveTask(rp,dr)} \wedge ar = AR_{at} \wedge (rp, dr) \in RPDRA)) \Rightarrow RPDRA' = RPDRA \backslash (rp, dr)$

– $\textsc{assignPDR}(auser \in AUser, ar \in AR, p \in P, dr \in DR) \equiv$
$((\text{subat} = \text{InclusiveTask(p,dr)} \wedge ar = AR_{subat} \wedge (dr, p) \notin PDRA)) \Rightarrow PDRA' = PDRA \cup (p, dr)$

– $\textsc{revokeRPDR}(auser \in AUser, ar \in AR, p \in P, dr \in DR) \equiv$
$((\text{at} = \text{InclusiveTask(p,dr)} \wedge ar = AR_{at} \wedge (p, dr) \in PDRA)) \Rightarrow PDRA' = PDRA \backslash (p, dr)$

Model Properties and Restrictions

- Model Properties:
  - Decoupled Assignment and Revocation
  - Symmetric Assignment and Revocation
  - Generalizability

- Model Restrictions:
  - Continuous Usage Control
  - Quota-based Access Enforcement
  - Conflict of Interest

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Conclusion and Future Directions

- In Conclusion:
  - We proposed an RBAC administrative model based on EGRBAC operational model in smart home environments.
  - We introduced the concept of administrative unit, which consists of a unique administrative role and a set of administrative tasks.

- Future Directions:
  - Address Model Constraints (continuous usage control, quota-based management
  - Device to Device (D2D) communication helps with providing an autonomous intelligence in IoT environments.

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Thank You
Any Questions?