RBAC-MAS & SODA: Experimenting RBAC in AOSE

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The Objective of this Paper

- Our work is aimed at discussing the methodological support provided by SODA, an AOSE methodology, for a particular security issue: the access control
- In order to do this we
  - present the *Role-Based Access Control* (RBAC) standard and its extension for MAS infrastructures (RBAC-MAS)
  - extract requirements for engineering an RBAC system
  - show how SODA supports these requirements
  - apply SODA to the engineering of a concrete case study— the management of the access control to a university building

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Access Control

- Access control is aimed at enabling (only) the authorised users to access the system resources in a controlled and supervised way
- Key aspect: the clear separation between
  - the access policy used to decide whether access to a resource should or not be granted for a given user
  - the hardware & software mechanisms actually enforcing such rules
- Such a separation is useful for two main reasons:
  - to uncouple the definition of a policy from its implementation, so that the latter is not affected by policy changes
  - to more easily identify the basic properties that any access control system should satisfy (complete mediation, default deny, minimum privilege, . . .)

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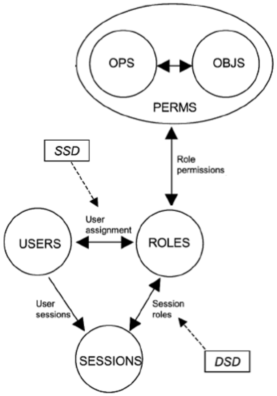

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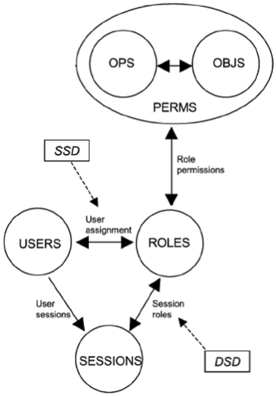

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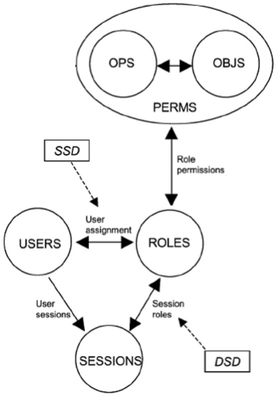

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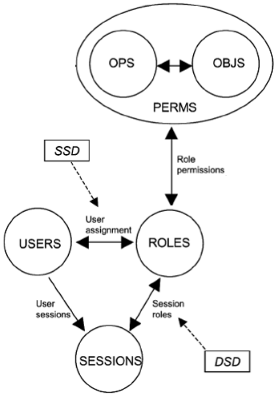

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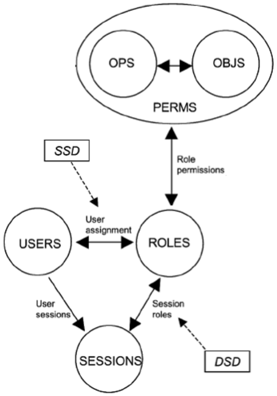

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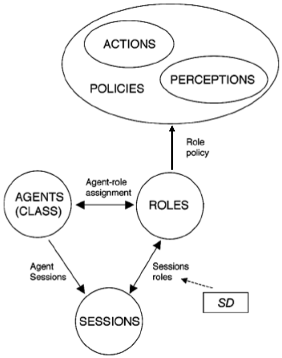
- Dynamic separation of duty (DSD) is achieved by placing constraints on the roles that can be activated within or across the given users' session

RBAC-MAS



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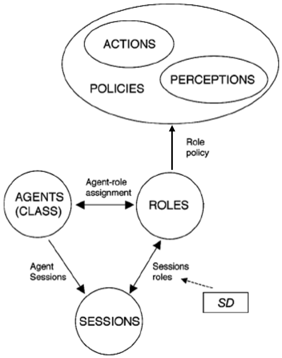

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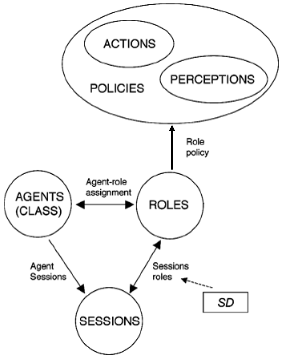

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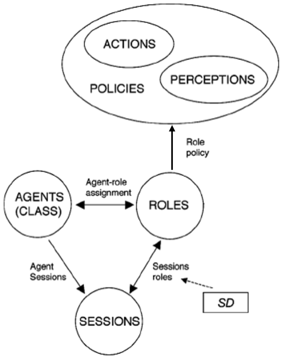

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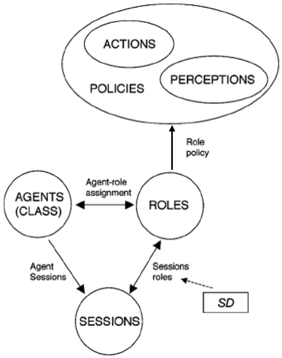

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- Agents' session starts with no activated roles
- Dynamics of role activation is constrained by the DSD rules

RBAC-MAS Requirements

- Role — supporting the modelling and design of both the user roles and the administrative roles
- Organisation — supporting the modelling and design of agent societies and the rules that govern them
- Object — hiding a lot of complexity:
  - able to model the environment of the MAS. . .
  - provide the physical and logical control to prevent unauthorised access. . .
  - . . . so, model and design both the topological structure and the resources that populate the environment
- Action and Perception — supporting the modelling and design of the actions that roles can perform over the objects and of the perceptions of the environment
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Policy and Mechanism Separation Requirements

- The separation between policy and mechanism introduces further constraints:
  - while such two sub-systems can be designed separately
  - they are indirectly coupled by the *representation language* of the access policies, since these are designed by one sub-system, but enforced by the other
  - it is not necessary to know the specific policy during the mechanism design phase: knowing how the policy is represented is relevant to choose the most appropriate storage and to decide the most adequate enforcing implementation
- The mechanism sub-system should manage the association between users and roles in a dynamic way:
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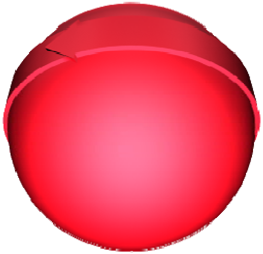
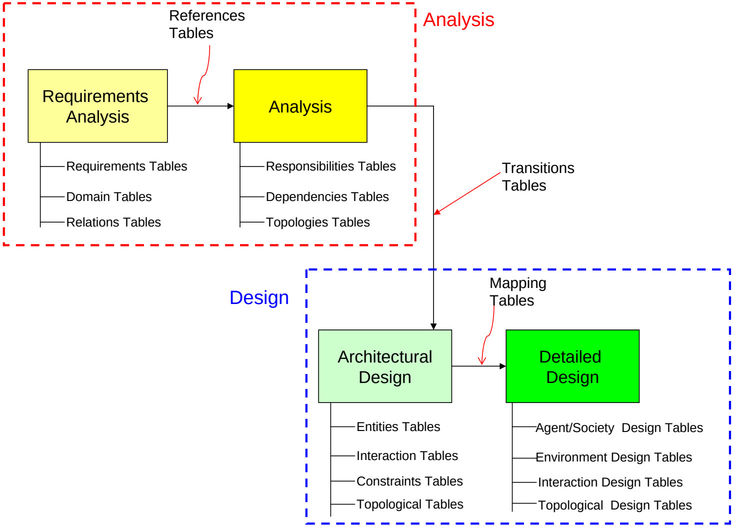
SODA: Societies in Open and Distributed Agent spaces

SODA . . .

- . . . is an agent-oriented methodology for the analysis and design of agent-based systems
- . . . focuses on inter-agent issues, like the engineering of societies and environment for MAS
- . . . adopts agents and artifacts – after the A&A meta-model – as the main building blocks for MAS development
- . . . introduces a simple *layering* principle in order to cope with the complexity of system description
- . . . adopts a tabular representation



SODA: Overview



A&A Meta-model

- Agents model individual and social activities
- Artifacts *glue* agents together, as well as MAS and the environment
  - artifacts mediate between individual agents and MAS
  - artifacts build up agent societies
  - artifacts wrap up the resources of MAS and bring them to the cognitive level of agents
- Workspaces structure agents and artifacts organisation & interaction

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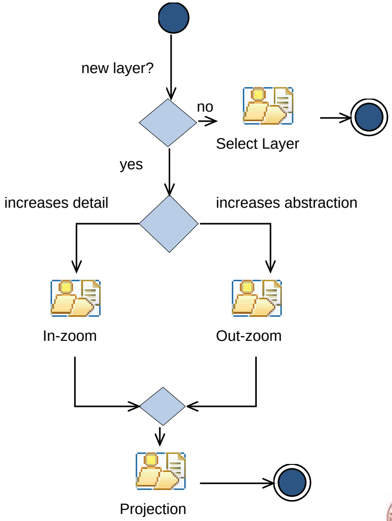
Layering in SODA

- The layering principle is achieved by means of the zoom and projection mechanisms
- Two kinds of zoom
  - in-zoom — from an abstract to a more detailed layer
  - out-zoom — from a detailed to a more abstract layer
- The *projection mechanism* projects entities from one to another layer



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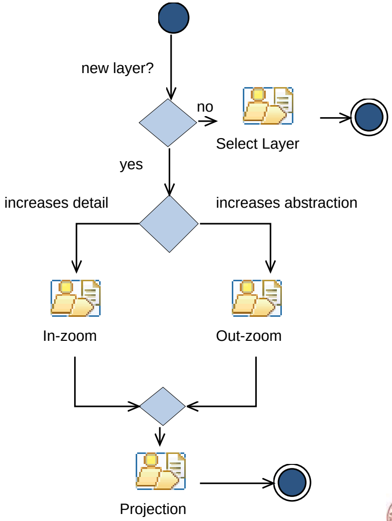

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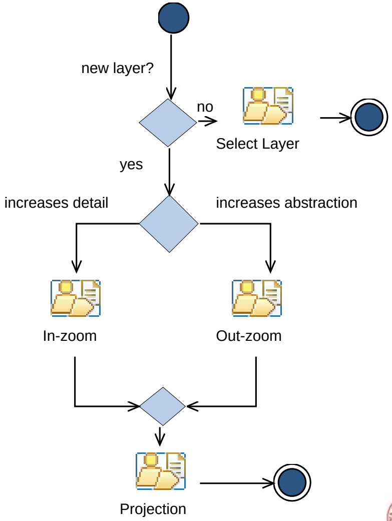

Outline

SODA&RBAC-MAS Requirements

RBAC-MAS	SODA
Role	*role*
Organisation	*societies and rules*
Object	*legacy-system, function, resource, artifact topology, space, workspace*
Action and Perception	*action, uses manifests*
Policy	*rule, artifact*
Policy language	*orthogonal to any language*
User-role association	*artifact*

- In the design of the mechanism sub-system only the reactive abstractions are involved
- In the design of the policy sub-system only the interactions and rules abstractions are used
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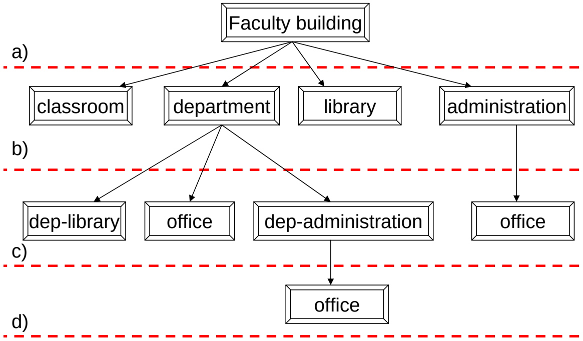
The Case Study

- Management of the access control to a university building
- Key system aspect:



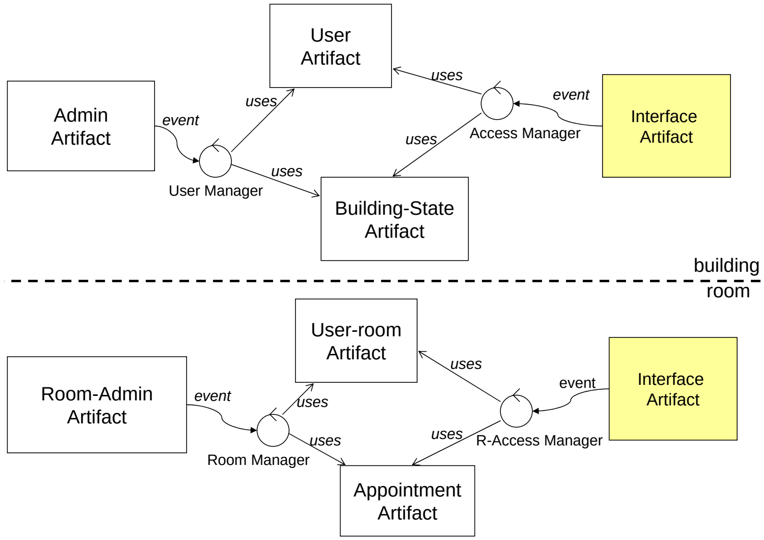
Outline

SODA's Tables

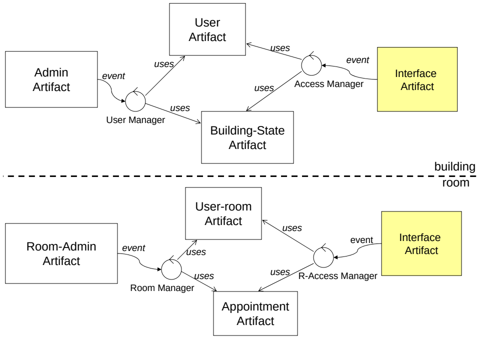
Space	Description
Faculty	the whole building
Classroom	the student space
Library	the faculty library
Department	the research centre
Administration	the faculty bureaucracy centre
Dep-Library	the department library
Dep-Administration	the department bureaucracy centre
Office	the rooms for employees

Space	Connection
Faculty	Classroom, Library, Department, Administration
Administration	Office
Department	Dep-Library, Dep-Administration, Office
Dep-Administration	Office

The mechanism

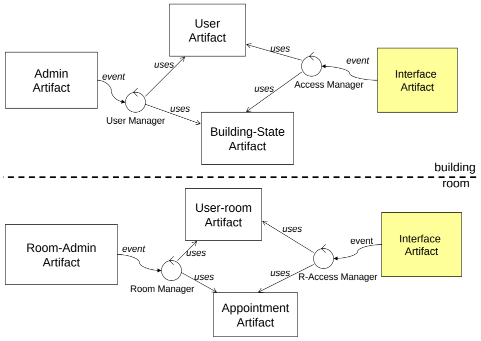


Mechanism’s Artifacts and Agents



- Interface Artifacts represent the wrappers to the hardware resources capturing the user credentials
- (Room-)Access Manager agents check whether such an access can be authorised
- User(-room) Artifacts store all the roles permanently qualified to access the building (room), along with their access privileges
- Building-State Artifact traces the people inside the building

Mechanism's Artifacts and Agents



- Appointment Artifact manages the users' appointments, storing the list of the appointments for a given room
- User Manager and Room Manager agents manage the system users
- (Room-)Admin Artifacts are used by the system administrator to introduce or delete roles and to edit the policies over time, or to handle appointments.

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- RBAC policies are designed during SODA's architectural design step
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The Roles

- From the viewpoint of sub-system requirements our scenario involves six different roles
    - Professors, Technicians, and Administrative staff can freely access the building at any time
    - Students can
        - access the building only during the regular opening hours
        - access the Administrative staffs' and Professors' offices only if they must have an appointment
    - Visitors cannot access the building without a Guide, who is a member of the University
- Beyond these roles, the user management activity highlights the need of a new service role – the System administrator – for modifying the access privileges and managing the users' credentials

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Roles & Actions

Role	**Action**
Visitor	enter, exit, ask_appointment
Student	enter, exit, ask_appointment
Professor	enter, exit, canc_appointment, set_appointment change_policy, insert_role, canc_role
Administrative staff	enter, exit, canc_appointment, set_appointment change_policy, insert_role, canc_role
Technician	enter, exit, canc_appointment, set_appointment change_policy, insert_role, canc_role
Guide	enter, exit
System administrator	enter, exit, change_policy insert_role, canc_role

Rules

Rule	Description
Guide-Rule	Guide cannot be activated together other roles (DSD constraint)
Visitor-Rule	Visitor cannot be activated together other roles (SSD constraint)
Admin-Rule	The Administrator can modify the access rules for the whole building but cannot modify the access rules for the offices
Prof-Admin-Rule	The Professor can modify the access rules for his/her office
Staff-Admin-Rule	The Administrative staff can modify the access rules for their office
Visit-Rule	Visitor can access the building only together a Guide
Building-Rule	The access to the building is possible only when the building is open to the public
Uni-Build-Rule	Professor, Technician, Administrative staff and System administrator can always access the building
App-Rule	The access to an office is granted only if the Student has an an appointment and the Professor/Administrative staff is in the office
Administration-Rule	The access to the staff office is possible only when the office is open to the public
ClassRoom-Rule	The access to a classroom is not granted during a lecture
Library-Rule	The access to the library is possible only when the library is open to the public
Lab-Rule	The access to the laboratory is possible only when the laboratory is open to the public
Department-Rule	The access to the department is possible only if the destination room grants the access

Rules&Artifacts

Rule	Description	
Guide-Rule	Guide cannot be activated together other roles (DSD constraint)	→ User Artifact
Visitor-Rule	Visitor cannot be activated together other roles (SSD constraint)	
Admin-Rule	The Administrator can modify the access rules for the whole building but cannot modify the access rules for the offices	
Prof-Admin-Rule	The Professor can modify the access rules for his/her office	→ (Room-)Admin Artifact
Staff-Admin-Rule	The Administrative staff can modify the access rules for their office	
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Library-Rule	The access to the library is possible only when the library is open to the public	→
Lab-Rule	The access to the laboratory is possible only when the laboratory is open to the public	Appointment Artifact
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Conclusion

- In this work we have shown how an AOSE methodology supports the design of an RBAC-MAS system
- with the purpose of
  - identifying the RBAC-MAS requirements
  - showing the suitability of the separation between policy and mechanism:
    - the mechanism sub-system is designed as general as possible, since its structure is basically stable and reusable as is in other applications
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Future Work

- Improving the methodology in several directions:
  - to support the design of secure agent-oriented systems since the earliest Requirement Analysis step
  - to develop a language for SODA rules able to capture all the relevant RBAC permissions and constraints
  - to study more deeply the access control issues related to artifacts

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