The Authorization Leap from Rights to Attributes: Maturation or Chaos?

Prof. Ravi Sandhu
Executive Director and Endowed Chair

SecurIT 2012
August 17, 2012

ravi.sandhu@utsa.edu
www.profsandhu.com
www.ics.utsa.edu

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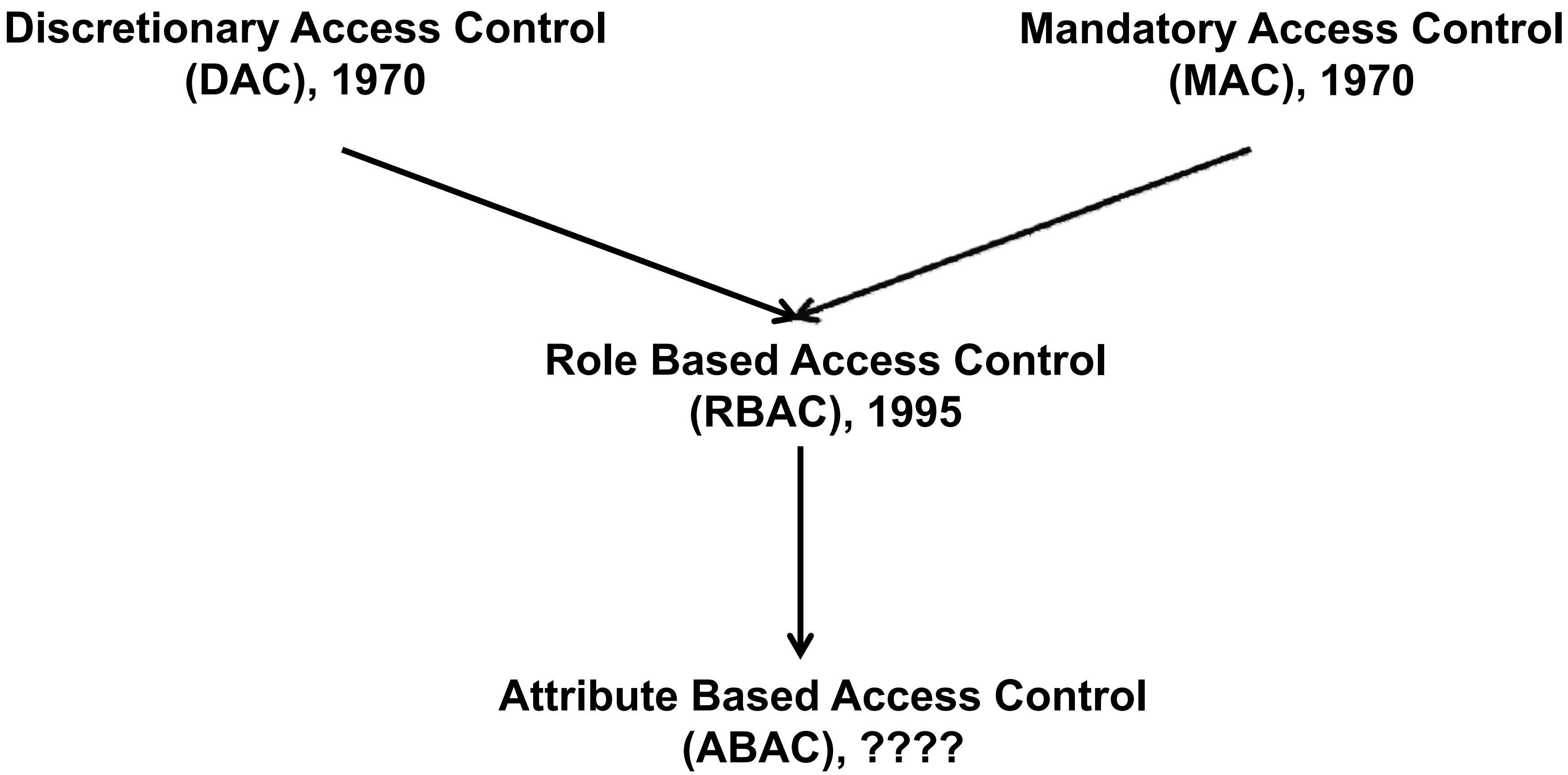
Prognosis: Cyberspace

- Cyberspace will become orders of magnitude more complex and confused very quickly

- Overall this is a very positive development and will enrich human society

- It will be messy but need not be chaotic!

Prognosis: Access Control



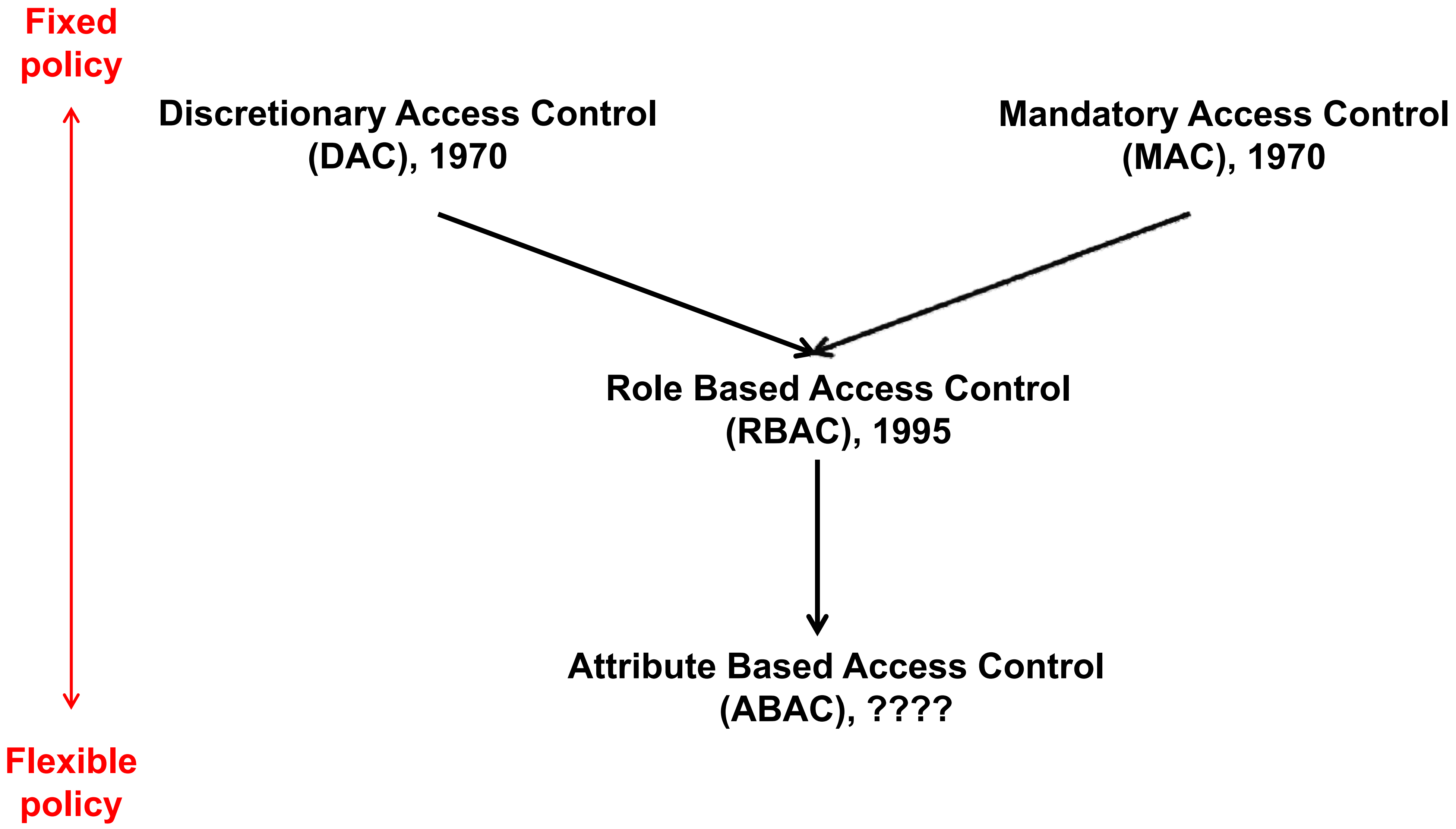
Discretionary Access Control (DAC), 1970

Mandatory Access Control (MAC), 1970

Role Based Access Control (RBAC), 1995

Attribute Based Access Control (ABAC), ????

Prognosis: Access Control



Fixed policy

Discretionary Access Control (DAC), 1970

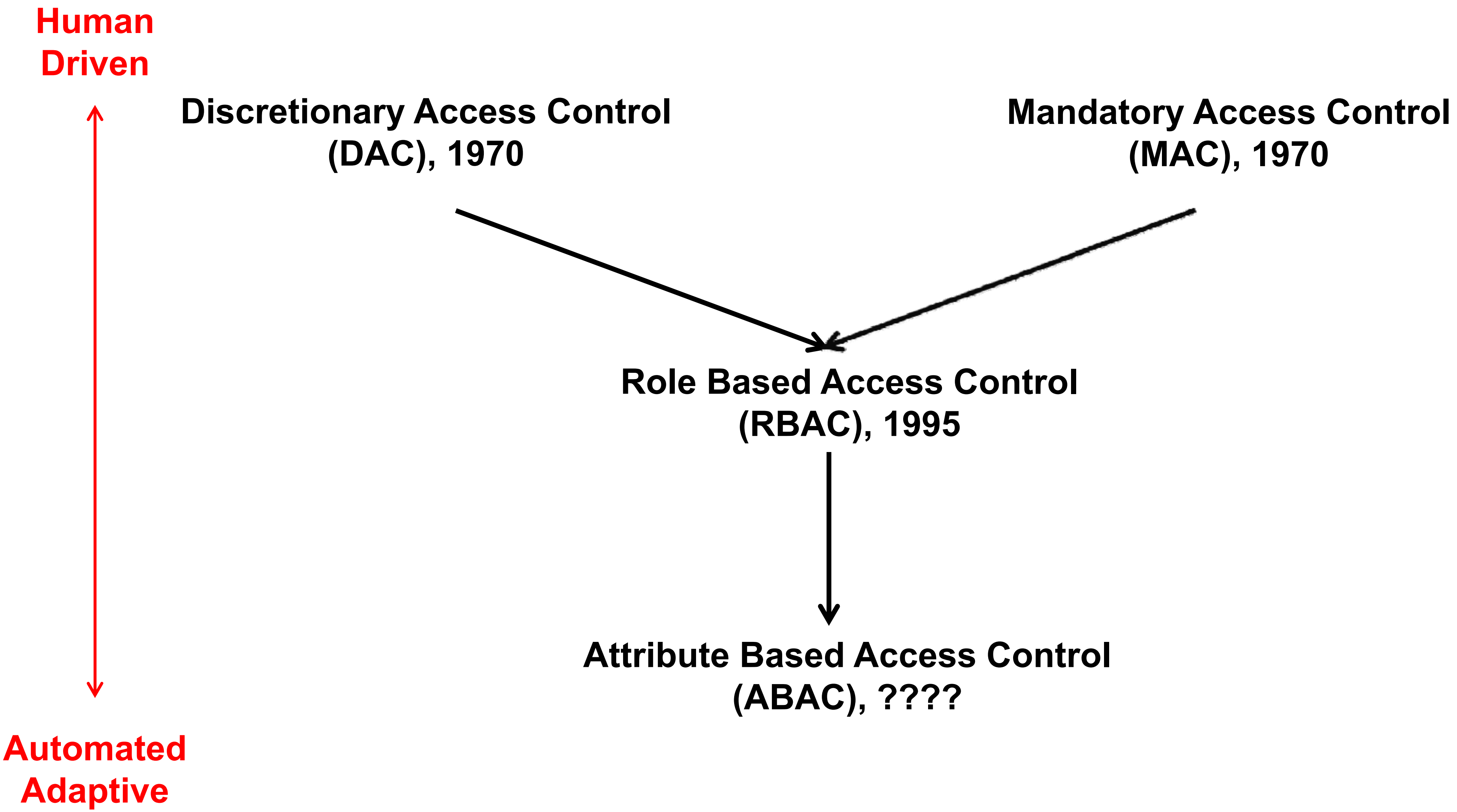
Mandatory Access Control (MAC), 1970

Role Based Access Control (RBAC), 1995

Attribute Based Access Control (ABAC), ????

Flexible policy

Prognosis: Access Control



Human Driven

Discretionary Access Control (DAC), 1970

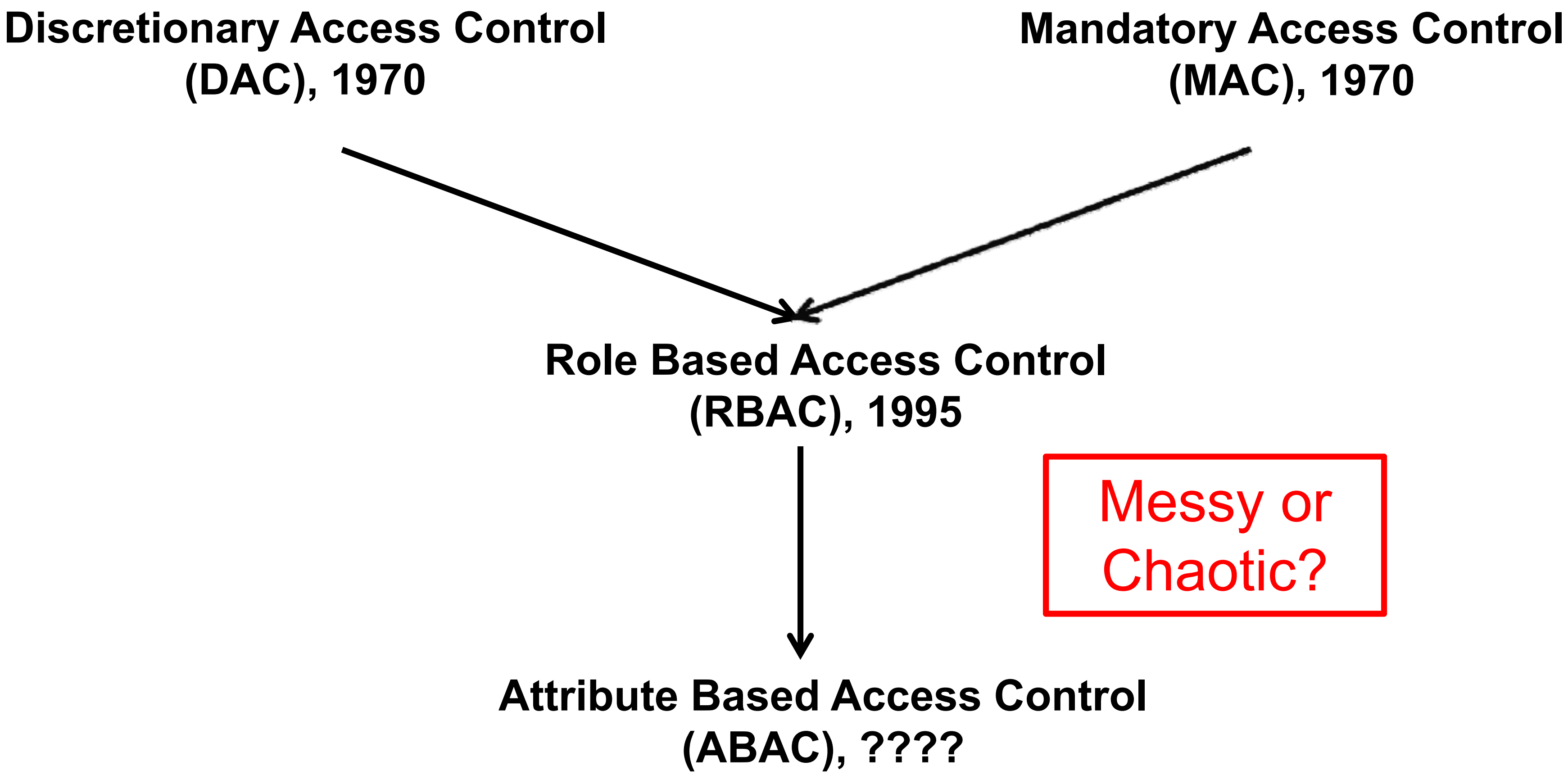
Mandatory Access Control (MAC), 1970

Role Based Access Control (RBAC), 1995

Attribute Based Access Control (ABAC), ????

Automated Adaptive

Prognosis: Access Control



Discretionary Access Control
(DAC), 1970

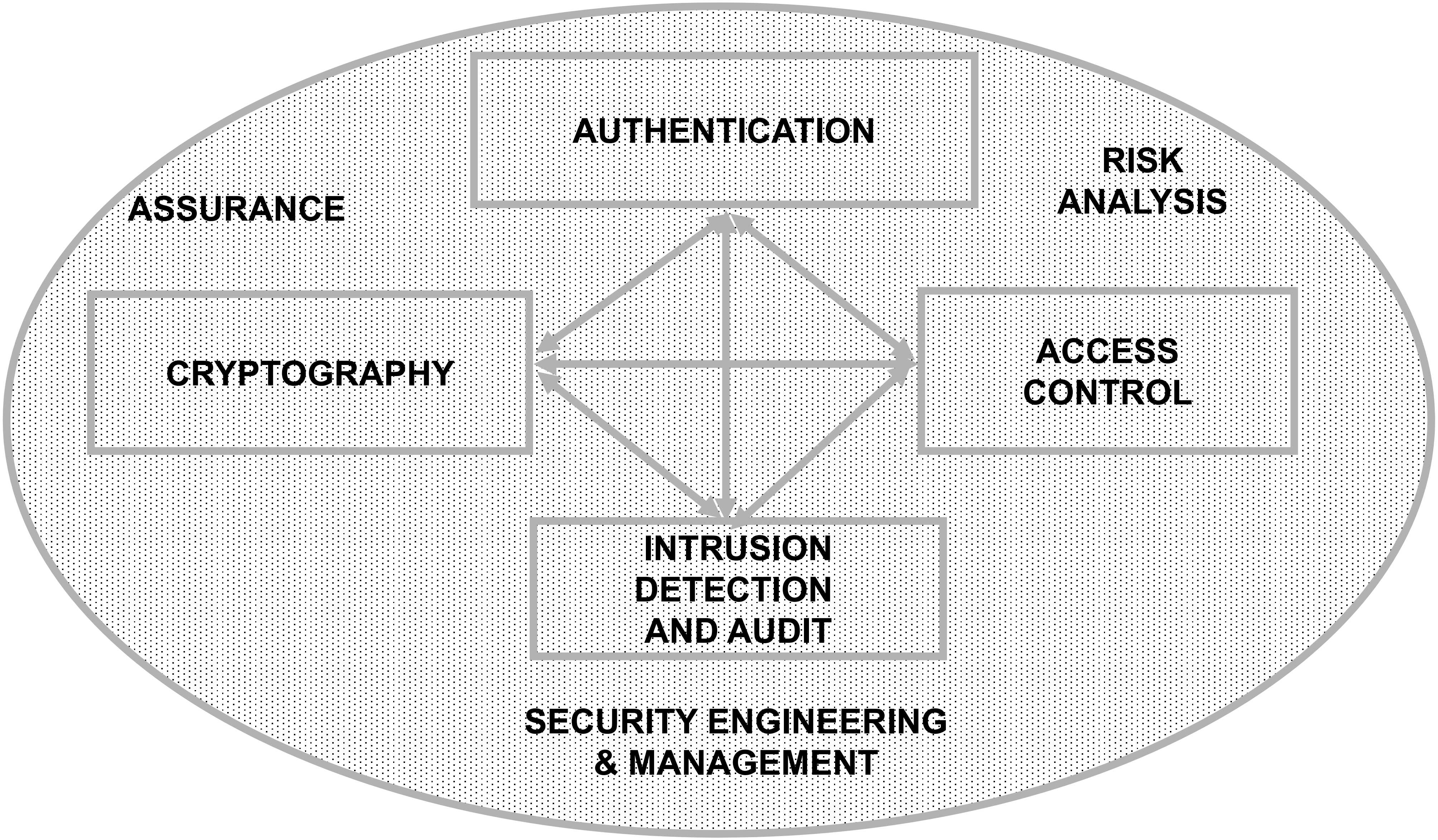
Mandatory Access Control
(MAC), 1970

Role Based Access Control
(RBAC), 1995

Messy or
Chaotic?

Attribute Based Access Control
(ABAC), ????

Cyber Security Technologies


AUTHENTICATION
ASSURANCE
RISK ANALYSIS
CRYPTOGRAPHY
ACCESS CONTROL
INTRUSION DETECTION AND AUDIT
SECURITY ENGINEERING & MANAGEMENT

Access Control Limitations

- Analog Hole
- Inference
- Covert Channels
- Side Channels
- Phishing
- Safety
- Usability
- Privacy
- Attack Asymmetry
- Compatibility
- Federation
- ….

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- ….

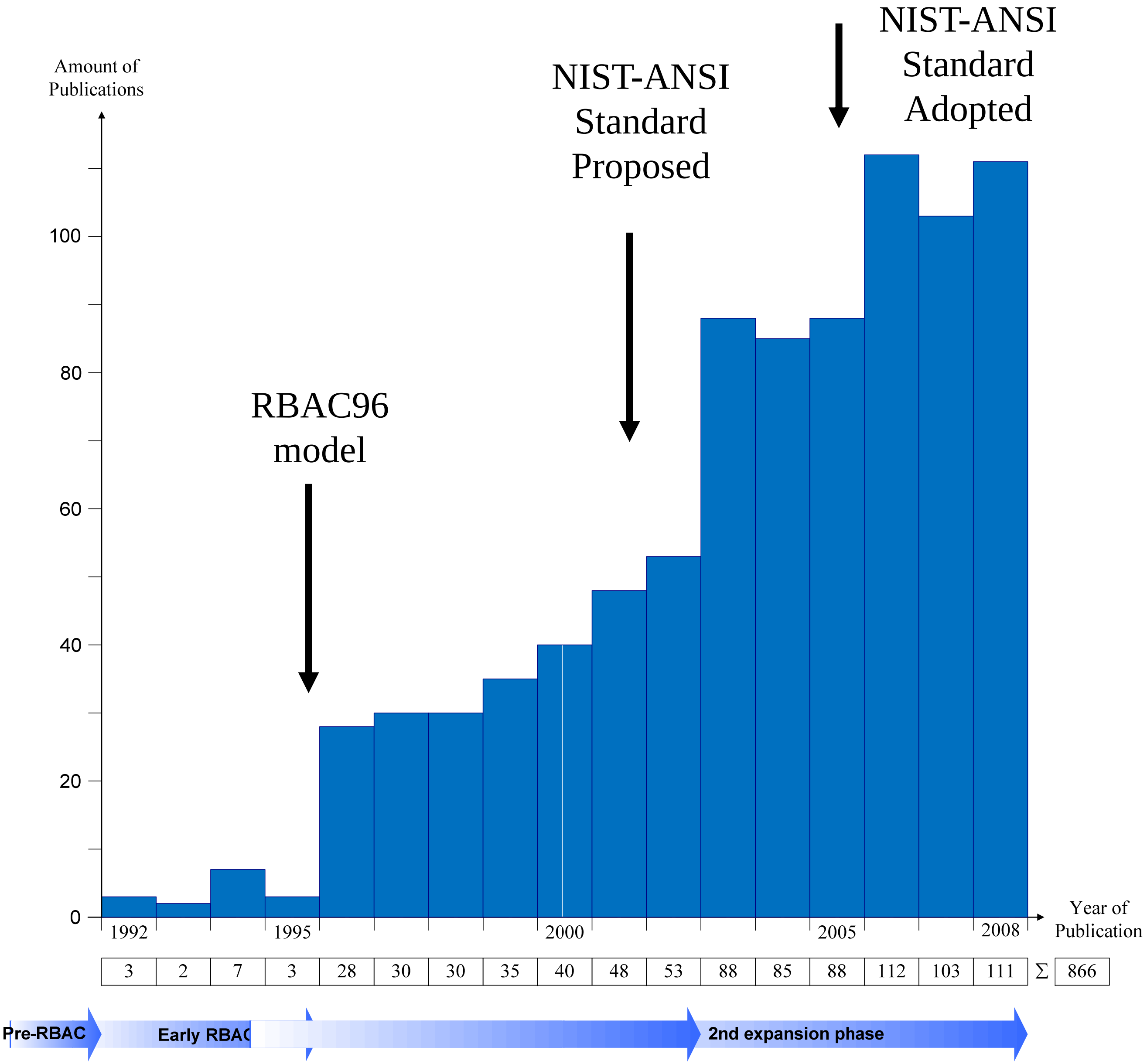
Can manage
Cannot eliminate

Access Control Models

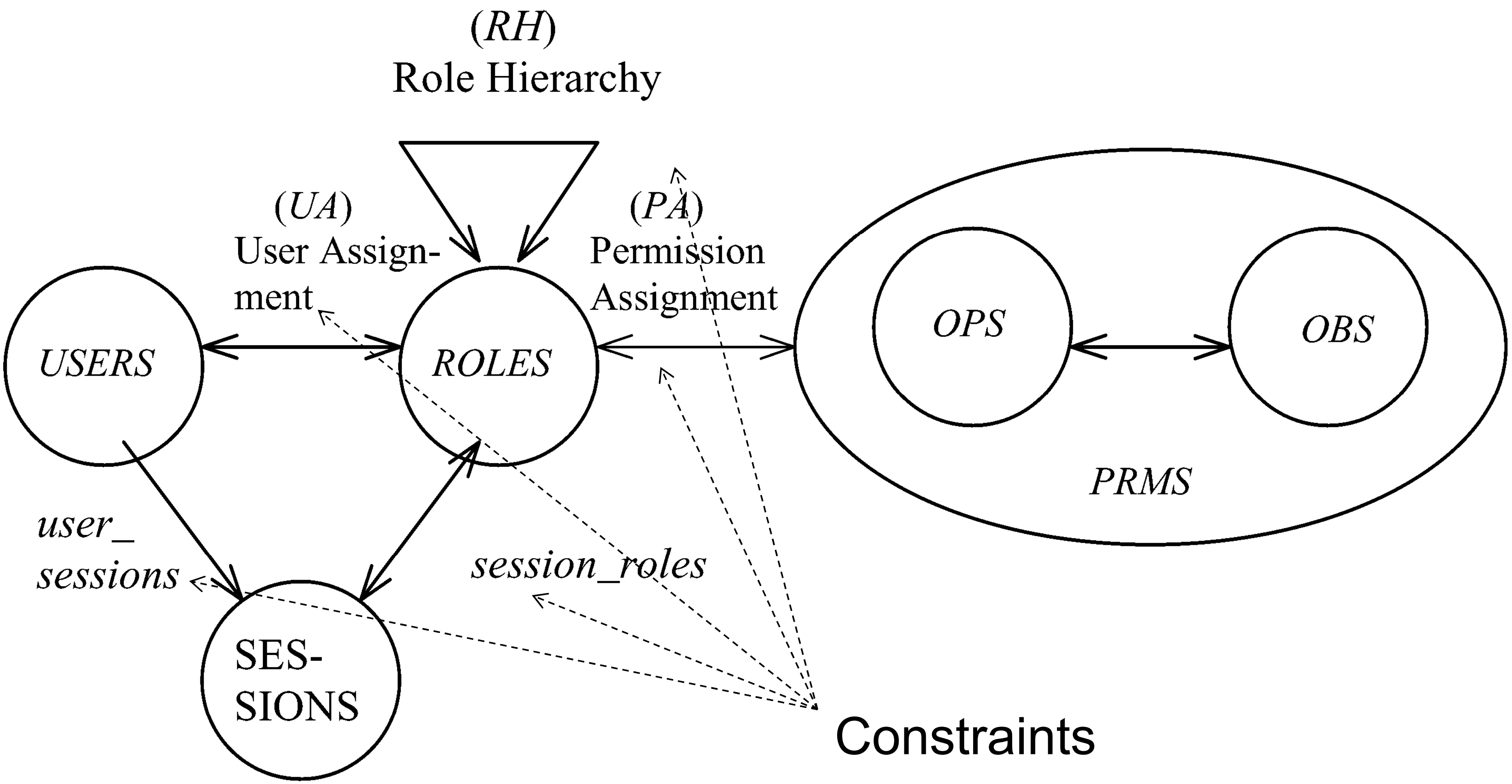
- Discretionary Access Control (DAC), 1970
  - Owner controls access
  - But only to the original, not to copies
  - Grounded in pre-computer policies of researchers
- Mandatory Access Control (MAC), 1970
  - Synonymous to Lattice-Based Access Control (LBAC)
  - Access based on security labels
  - Labels propagate to copies
  - Grounded in pre-computer military and national security policies
- Role-Based Access Control (RBAC), 1995
  - Access based on roles
  - Can be configured to do DAC or MAC
  - Grounded in pre-computer enterprise policies

Numerous other models but only 3 successes: SO FAR

The RBAC Story



RBAC96 Model



Fundamental Theorem of RBAC

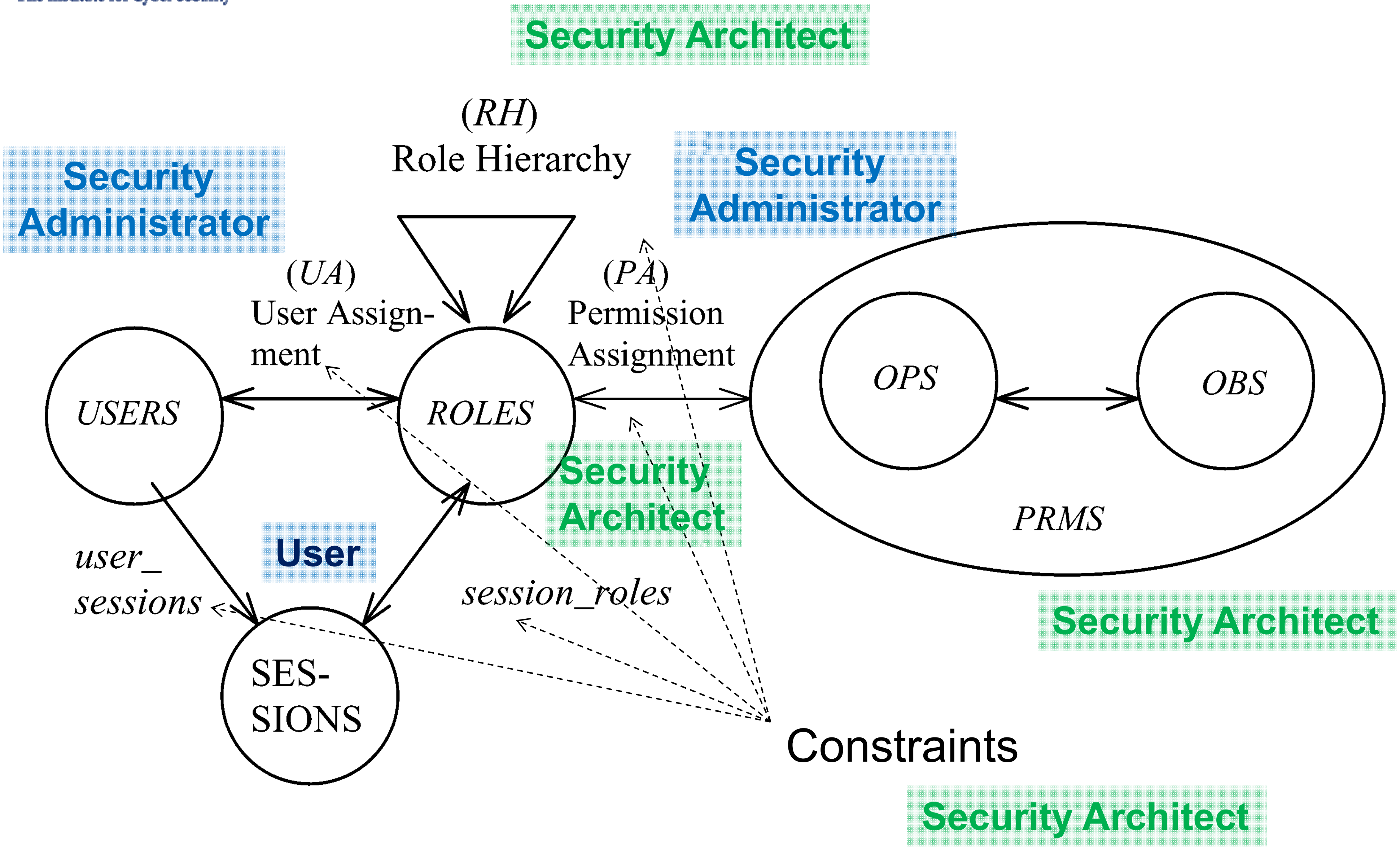
- RBAC can be configured to do MAC
- RBAC can be configured to do DAC
- RBAC is policy neutral

RBAC is neither MAC nor DAC!

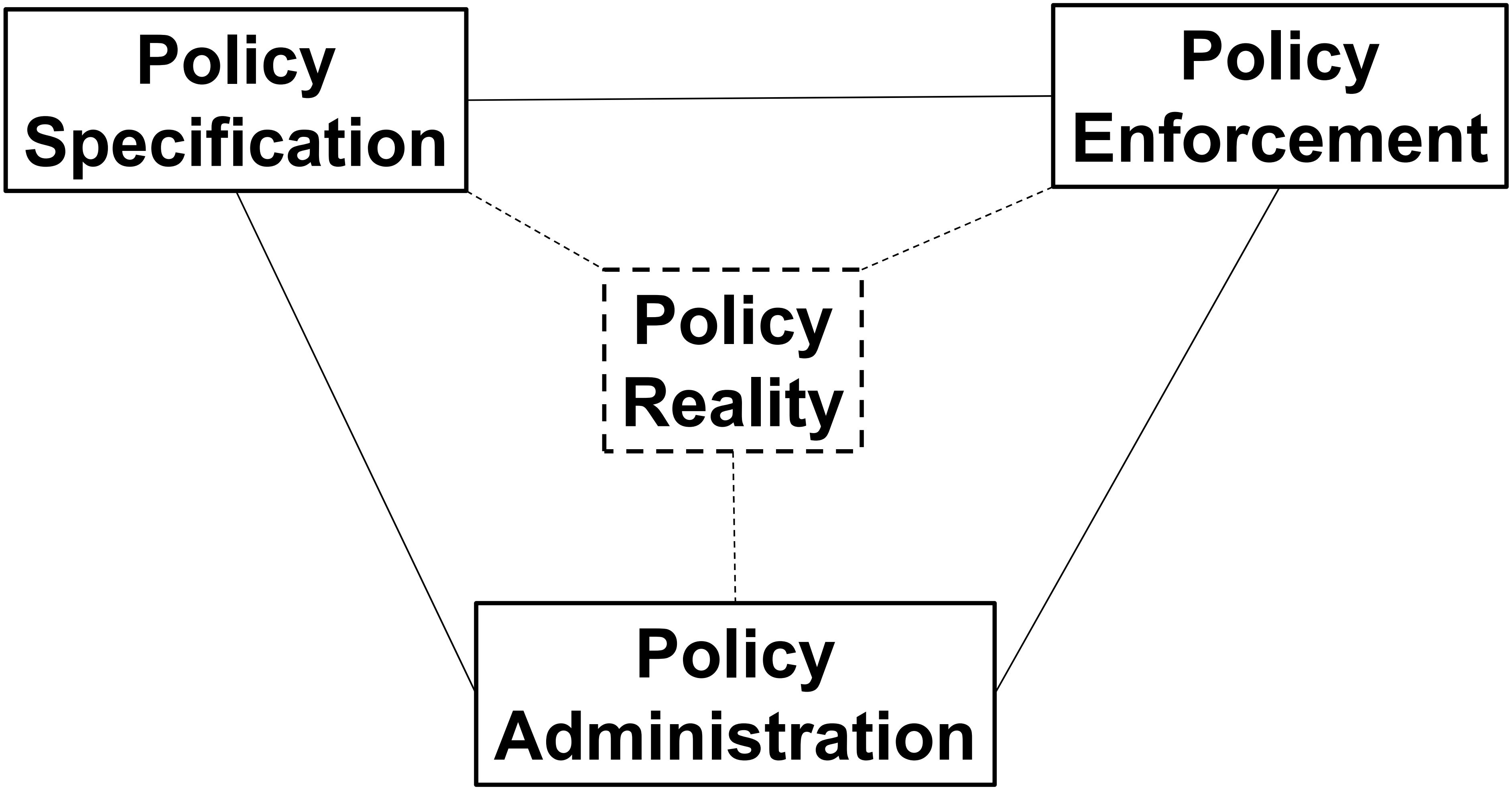
RBAC Shortcomings

- Role granularity is not adequate leading to role explosion
  - Researchers have suggested several extensions such as parameterized privileges, role templates, parameterized roles (1997-)
- Role design and engineering is difficult and expensive
  - Substantial research on role engineering top down or bottom up (1996-), and on role mining (2003-)
- Assignment of users/permissions to roles is cumbersome
  - Researchers have investigated decentralized administration (1997-), attribute-based implicit user-role assignment (2002-), role-delegation (2000-), role-based trust management (2003-), attribute-based implicit permission-role assignment (2012-)
- Adjustment based on local/global situational factors is difficult
  - Temporal (2001-) and spatial (2005-) extensions to RBAC proposed
- RBAC does not offer an extension framework
  - Every shortcoming seems to need a custom extension
  - Can ABAC unify these extensions in a common open-ended framework?

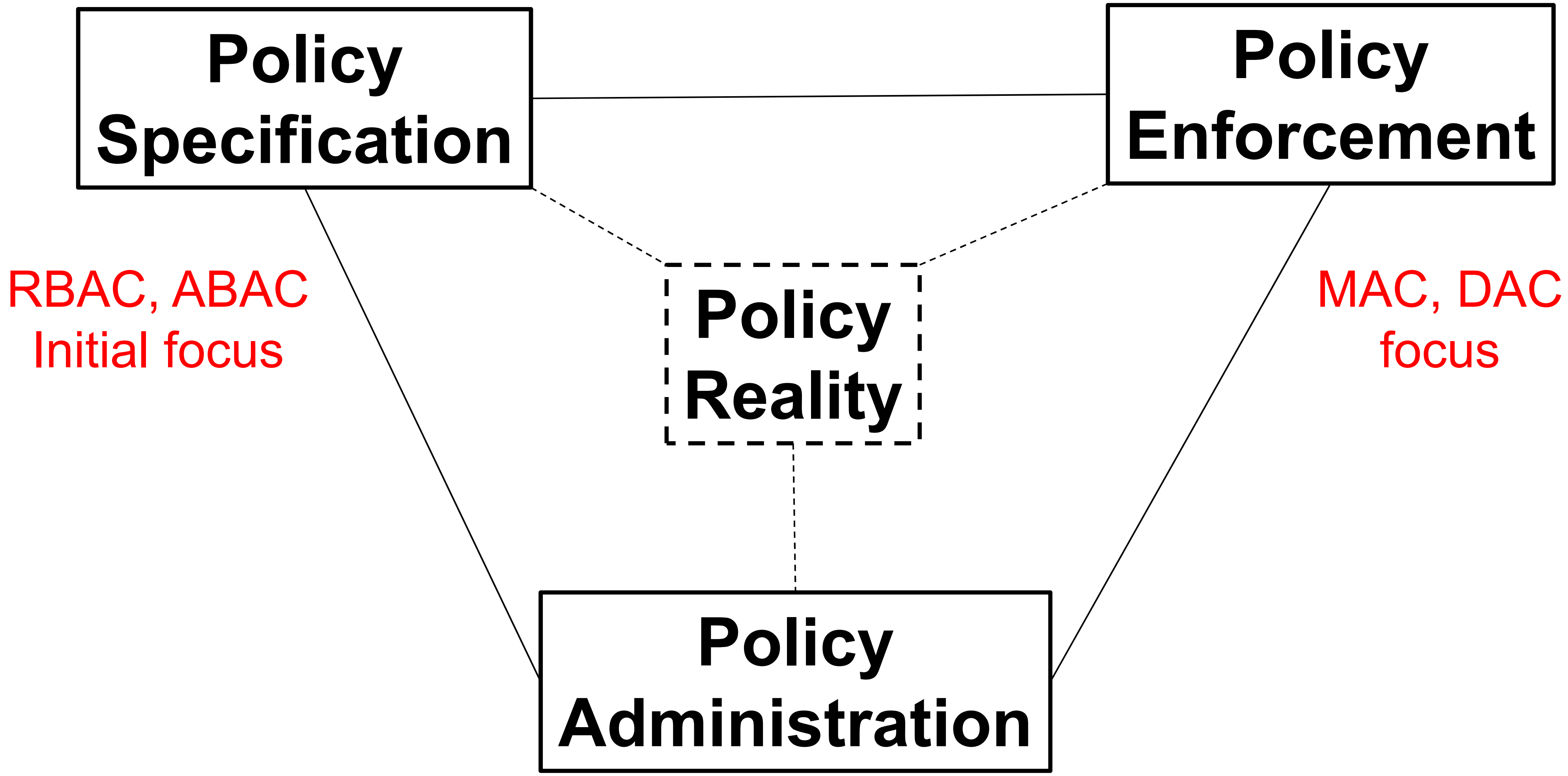
RBAC Policy Configuration Points



Access Control Models



Access Control Models


Policy Specification

Policy Enforcement

Policy Reality

Policy Administration

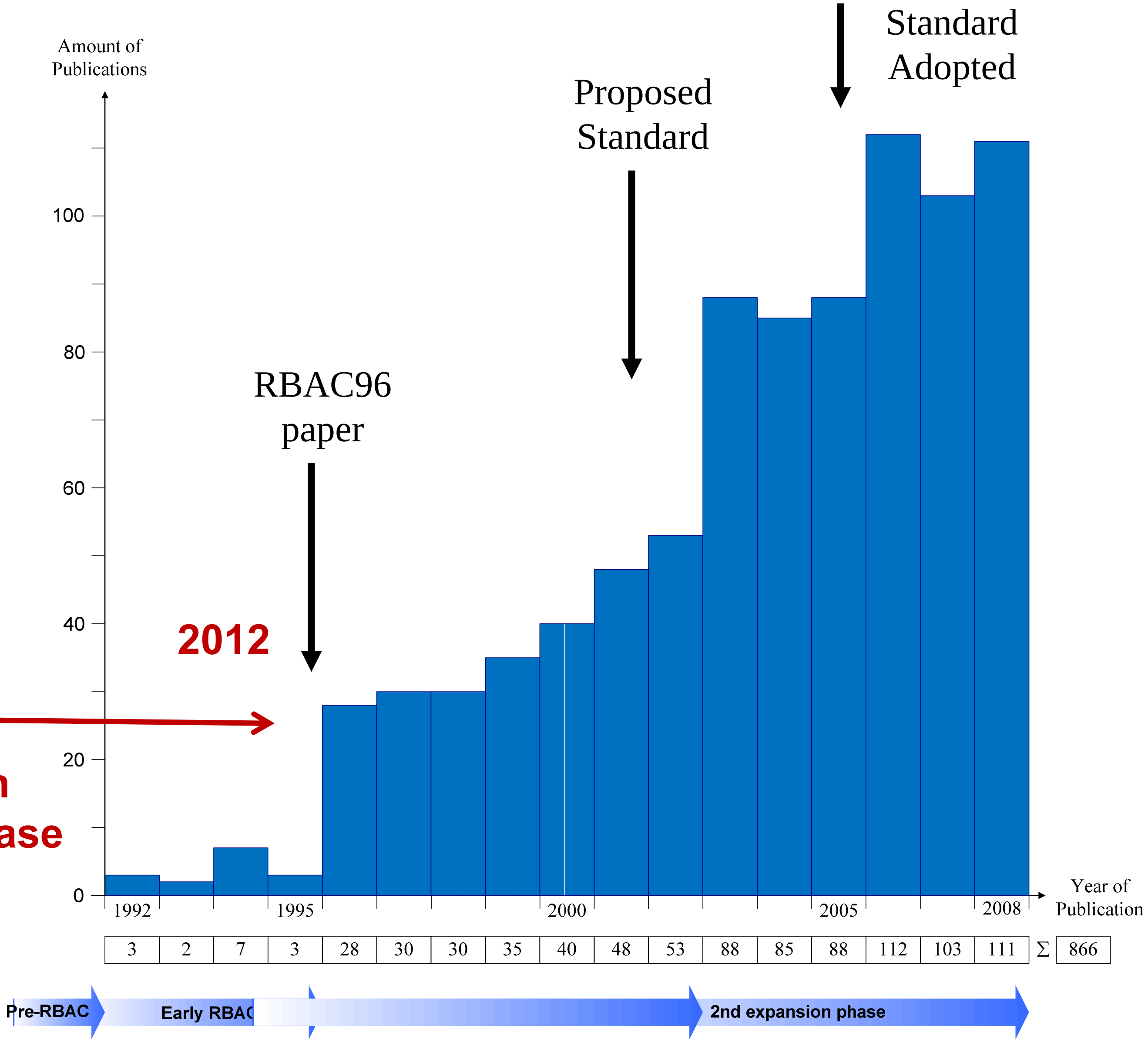
RBAC, ABAC
Initial focus

MAC, DAC
focus

Attribute-Based Access Control (ABAC)

- Attributes are name:value pairs
  - possibly chained
  - values can be complex data structures
- Associated with
  - users
  - subjects
  - objects
  - contexts
    - device, connection, location, environment, system …
- Converted by policies into rights just in time
  - policies specified by security architects
  - attributes maintained by security administrators
  - ordinary users morph into architects and administrators
- Inherently extensible

ABAC Status



1990?

2012

ABAC still in pre/early phase

ABAC Prior Work Includes

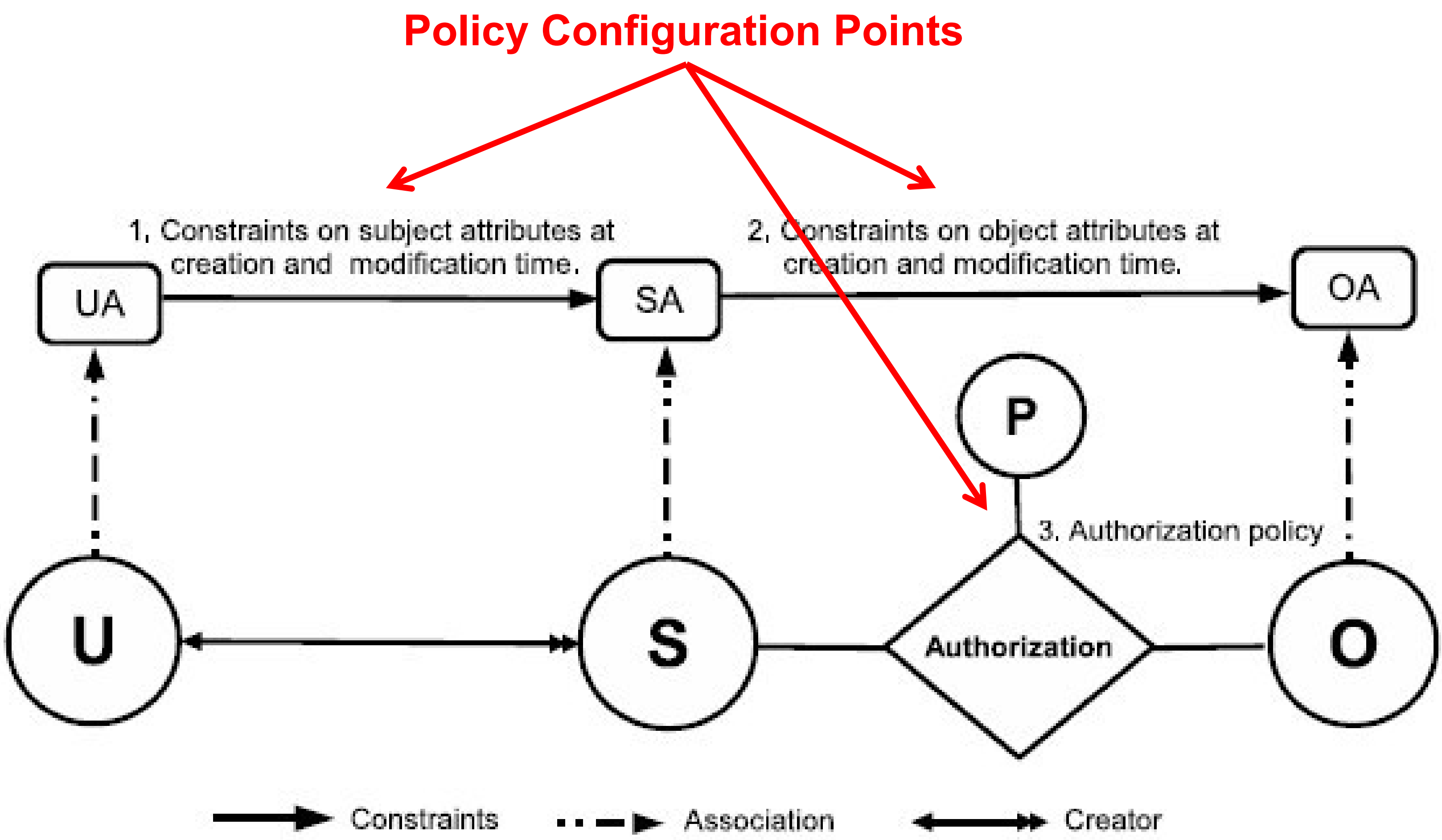
- X.509, SPKI Attribute Certificates (1999 onwards)
  - IETF RFCs and drafts
  - Tightly coupled with PKI (Public-Key Infrastructure)
- XACML (2003 onwards)
  - OASIS standard
  - Narrowly focused on particular policy combination issues
  - Fails to accommodate the ANSI-NIST RBAC standard model
  - Fails to address user subject mapping
- Usage Control or UCON (Park-Sandhu 2004)
  - Fails to address user subject mapping
  - Focus is on extended features
    - Mutable attributes
    - Continuous enforcement
    - Obligations
    - Conditions
- Several others ………..

ABACα Hypothesis (DBSEC 2012)

- An ABAC model requires
  - identification of policy configuration points (PCPs)
  - languages and formalisms for each PCP
- A core set of PCPs can be discovered by building the ABACα model to unify DAC, MAC and RBAC
- Additional ABAC models can then be developed by
  - increasing the sophistication of the ABACα PCPs
  - discovering additional PCPs driven by requirements beyond DAC, MAC and RBAC

A small but crucial step

ABACα Model Structure


Policy Configuration Points
1, Constraints on subject attributes at creation and modification time.
2, Constraints on object attributes at creation and modification time.
UA
SA
OA
P
3. Authorization policy
U
S
Authorization
O
Constraints
Association
Creator

Authorization Policy: LAuthorization

- ❖DAC

$$Authorization_{read}(s,o) \equiv SubCreator(s) \in reader(o)$$

$$Authorization_{write}(s,o) \equiv SubCreator(s) \in writer(o)$$

- ❖MAC

$$Authorization_{read}(s,o) \equiv sensitivity(o) \leq sclearance(s)$$

$$\text{Liberal star}: Aauthorization_{write}(s,o) \equiv sclearance(s) \leq sensitivity(o)$$

$$\text{Strict star}: Aauthorization_{write}(s,o) \equiv sensitivity(o) = sclearance(s)$$

- ❖RBAC0

$$Authorization_{read}(s,o) \equiv \exists r \in srole(s).r \in rrole(o)$$

- ❖RBAC1

$$Authorization_{read}(s,o) \equiv \exists r1 \in srole(s).\exists r2 \in rrole(o).r2 \leq r1$$

Subject Attribute Constraints ; LConstrSub

- ❖MAC $ConstrSub(u, s, \{(sclearance, value)\}) \equiv value \leq uclearance(u)$

- ❖RBAC0 $ConstrSub(u, s, \{srole, value\}) \equiv value \subseteq urole(u)$

- ❖RBAC1 $ConstrSub(u, s, \{srole, value\}) \equiv \forall r1 \in value . \exists r2 \in urole(u) . r1 \leq r2$

Object Attribute Constraints

Constraints at creation: LConstrObj

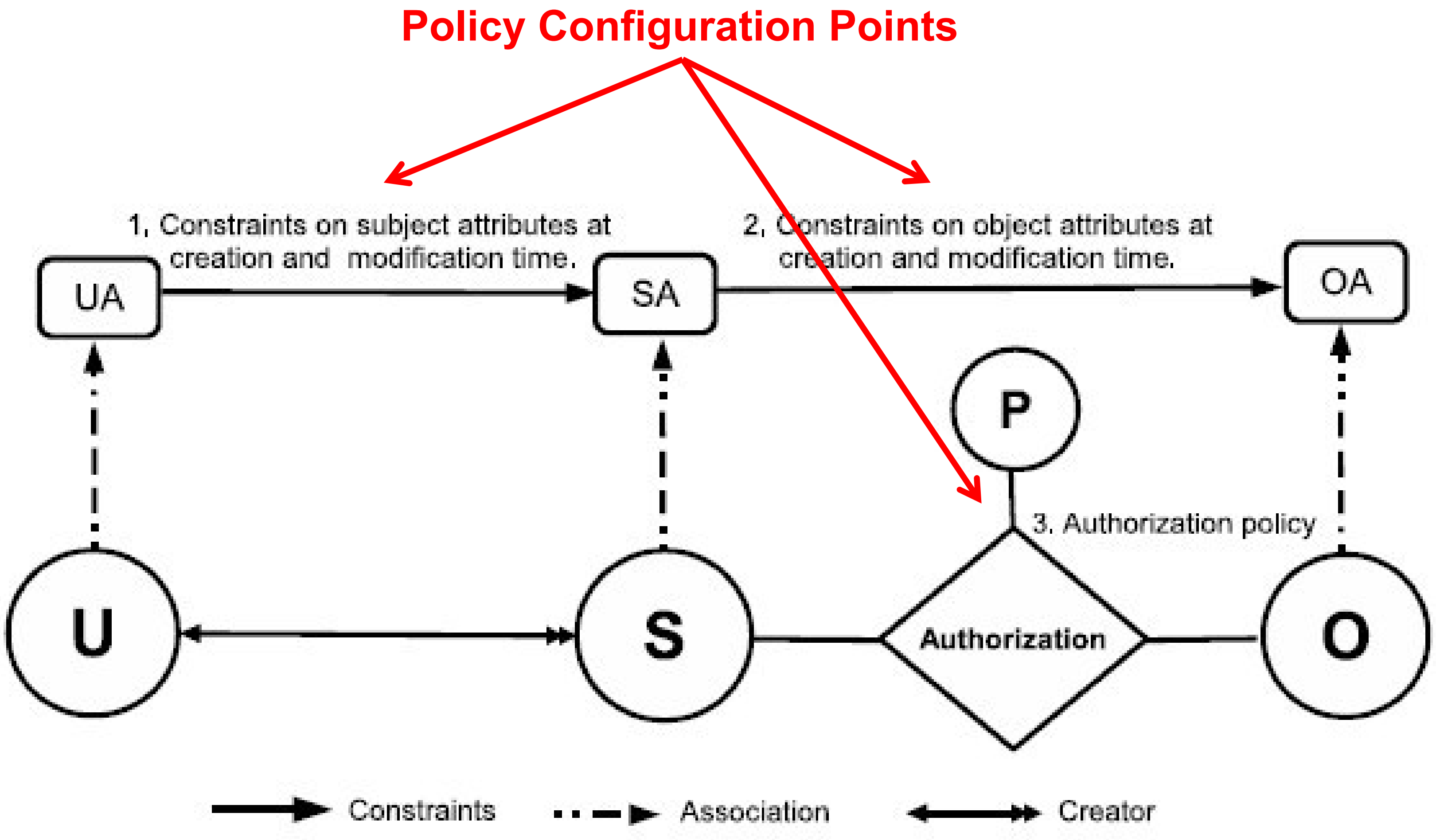
- ❖DAC $ConstrObj(s,o,\{(reader,val1),(writer,val2),(createdby,val3)\}) \equiv$ $val3 = SubCreator(s)$

- ❖MAC $ConstrObj(s,o,\{sensitivity,value\}) \equiv sclearance(s) \leq value$

Constraints at modification: LConstrObjMod

- ❖DAC $ConstrObj(s,o,\{(reader,val1),(writer,val2),(createdby,val3)\}) \equiv$ $createdby(o) = SubCreator(s)$

ABACα Model Structure



Policy Configuration Points

1. Constraints on subject attributes at creation and modification time.

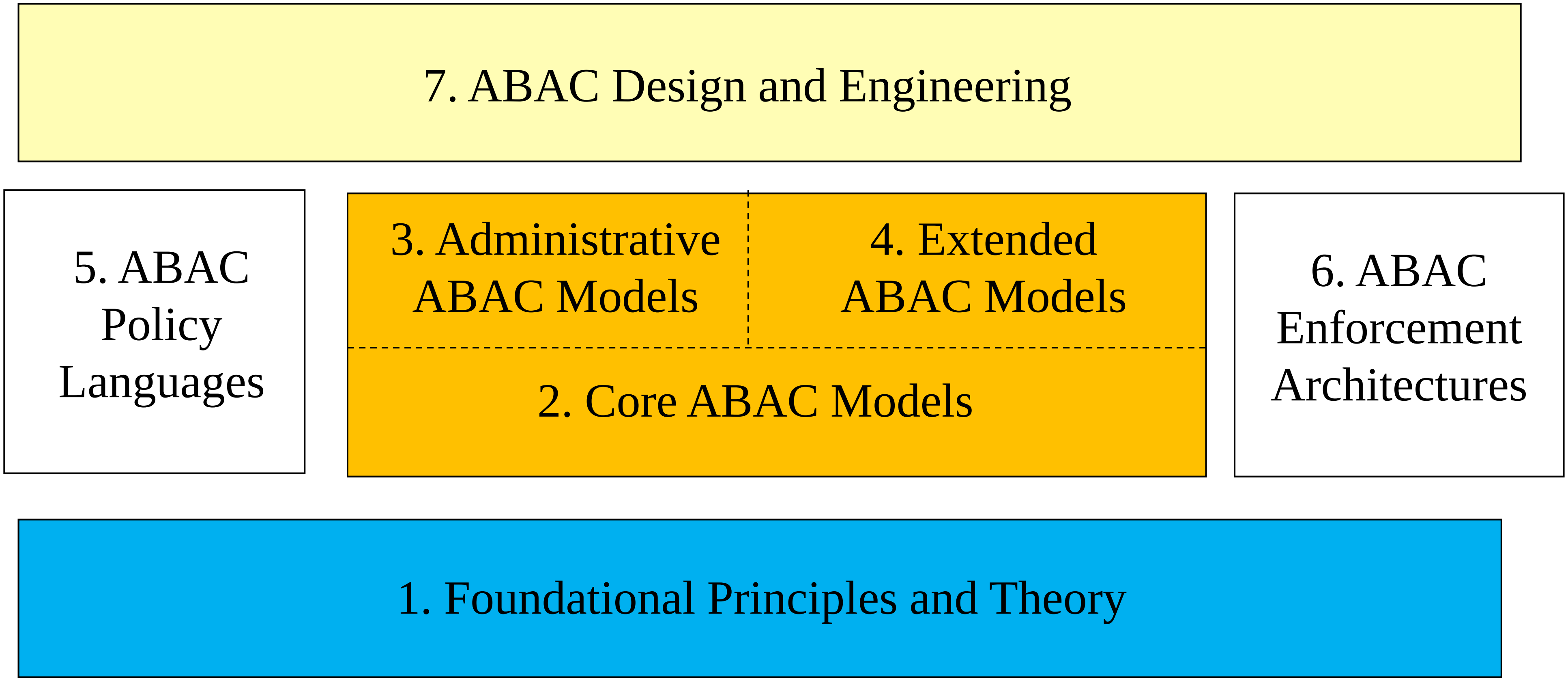
2. Constraints on object attributes at creation and modification time.

3. Authorization policy

Future work

- ❖ **increasing the sophistication of the ABACα PCPs**
- ❖ **discovering additional PCPs**

ABAC Research Agenda



7. ABAC Design and Engineering

5. ABAC Policy Languages

3. Administrative ABAC Models

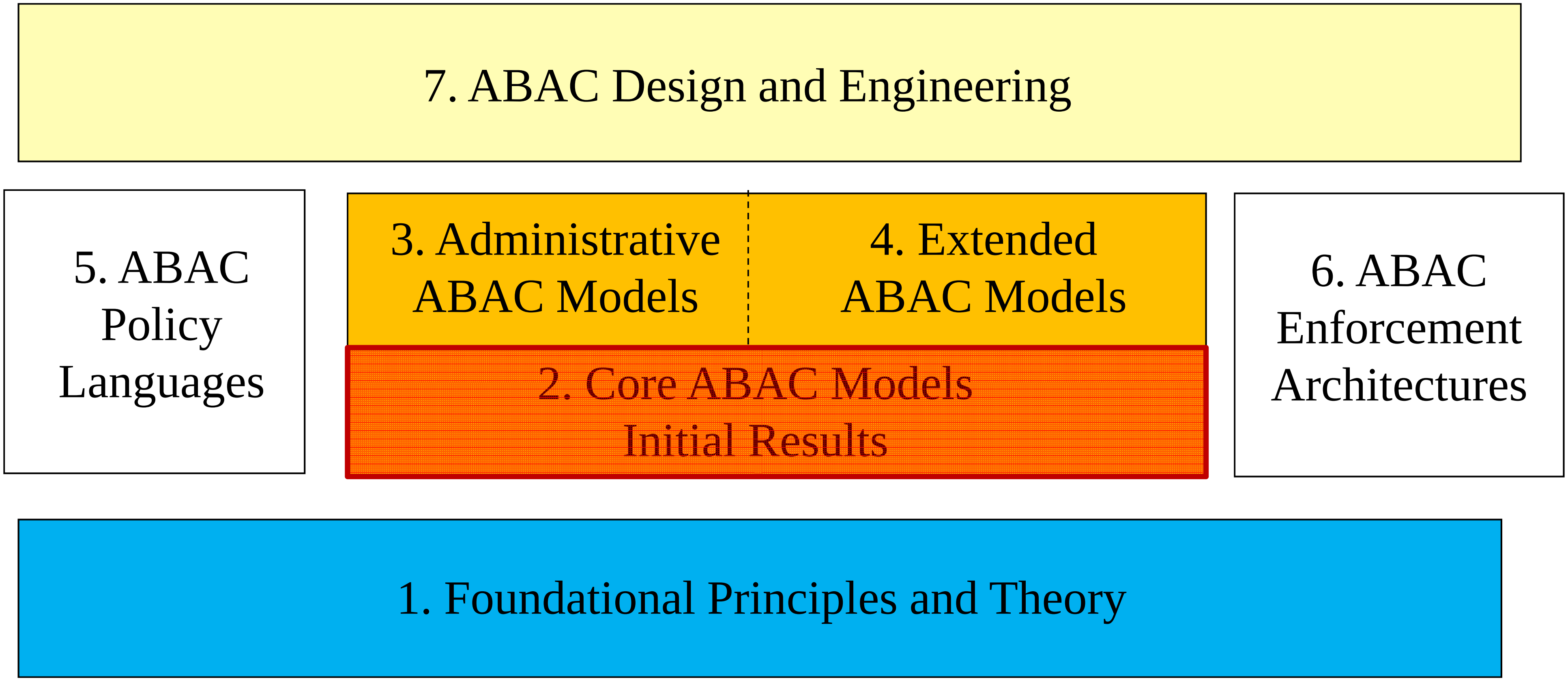
4. Extended ABAC Models

2. Core ABAC Models

6. ABAC Enforcement Architectures

1. Foundational Principles and Theory

ABAC Research Agenda


7. ABAC Design and Engineering

5. ABAC Policy Languages

3. Administrative ABAC Models

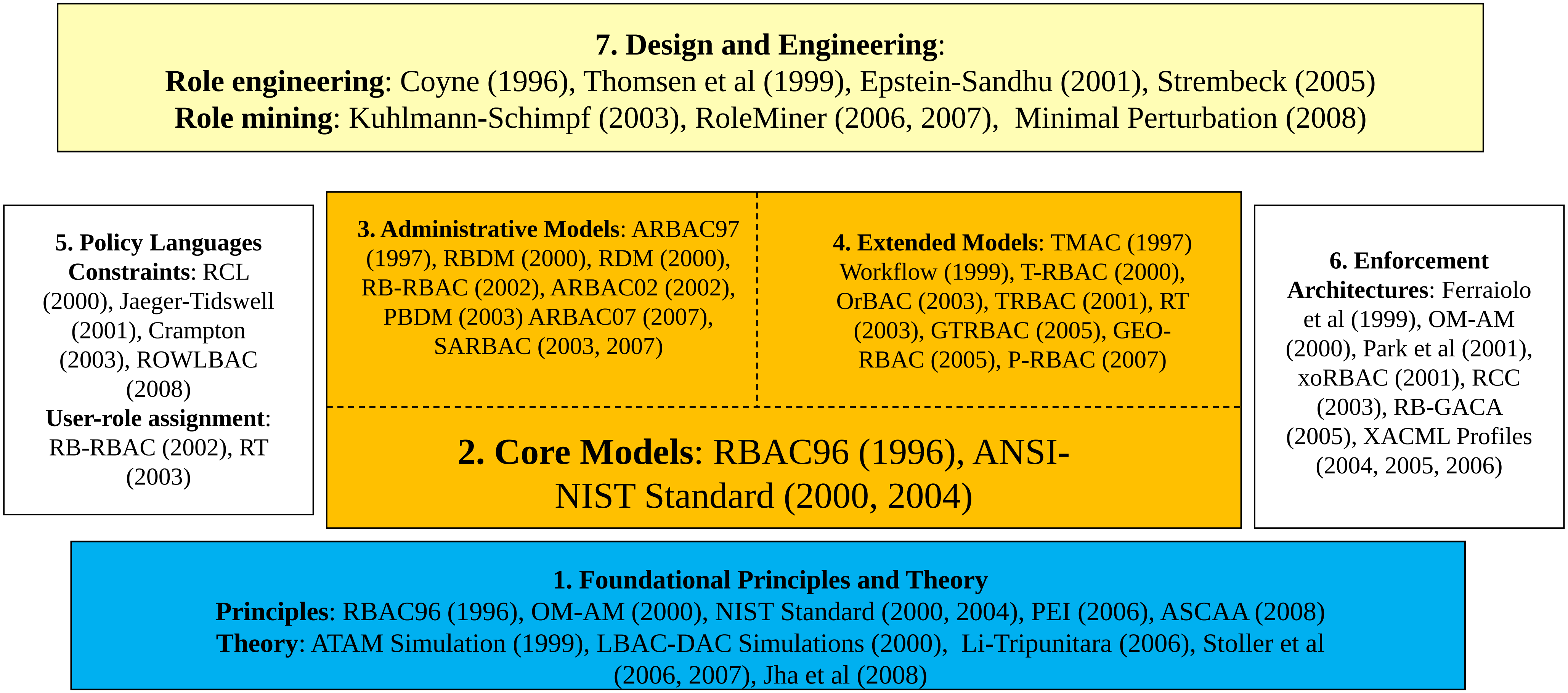
4. Extended ABAC Models

2. Core ABAC Models Initial Results

6. ABAC Enforcement Architectures

1. Foundational Principles and Theory

ABAC Research Agenda: RBAC Inspiration



7. Design and Engineering:
Role engineering: Coyne (1996), Thomsen et al (1999), Epstein-Sandhu (2001), Strembeck (2005)
Role mining: Kuhlmann-Schimpf (2003), RoleMiner (2006, 2007), Minimal Perturbation (2008)

5. Policy Languages
Constraints: RCL (2000), Jaeger-Tidswell (2001), Crampton (2003), ROWLBAC (2008)
User-role assignment: RB-RBAC (2002), RT (2003)

3. Administrative Models: ARBAC97 (1997), RBDM (2000), RDM (2000), RB-RBAC (2002), ARBAC02 (2002), PBDM (2003) ARBAC07 (2007), SARBAC (2003, 2007)

4. Extended Models: TMAC (1997) Workflow (1999), T-RBAC (2000), OrBAC (2003), TRBAC (2001), RT (2003), GTRBAC (2005), GEO-RBAC (2005), P-RBAC (2007)

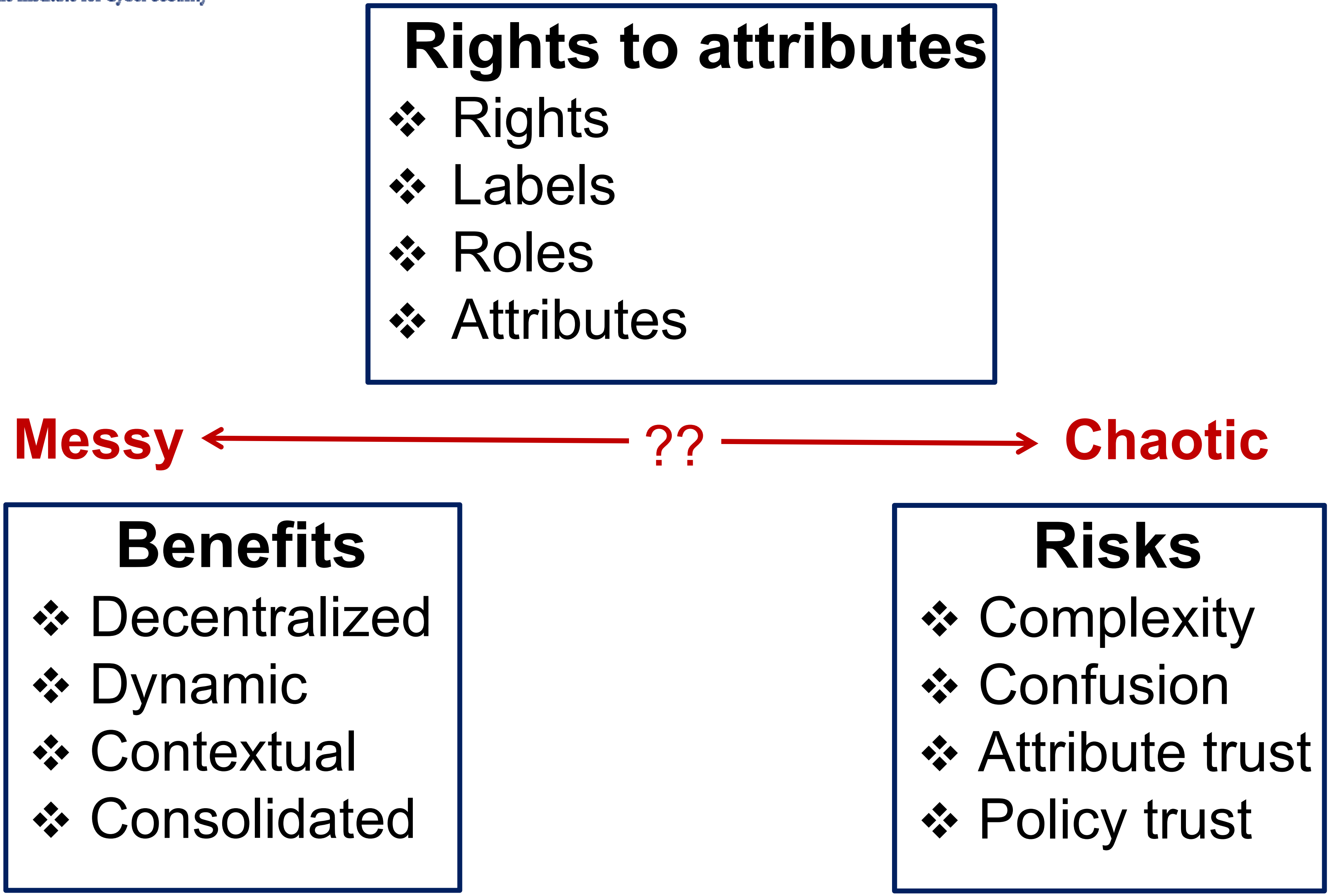
2. Core Models: RBAC96 (1996), ANSI-NIST Standard (2000, 2004)

6. Enforcement Architectures: Ferraiolo et al (1999), OM-AM (2000), Park et al (2001), xoRBAC (2001), RCC (2003), RB-GACA (2005), XACML Profiles (2004, 2005, 2006)

1. Foundational Principles and Theory
Principles: RBAC96 (1996), OM-AM (2000), NIST Standard (2000, 2004), PEI (2006), ASCAA (2008)
Theory: ATAM Simulation (1999), LBAC-DAC Simulations (2000), Li-Tripunitara (2006), Stoller et al (2006, 2007), Jha et al (2008)

NOTE: Only a small sampling of the RBAC literature is cited in this diagram

Authorization Leap



Rights to attributes

- ❖ Rights
- ❖ Labels
- ❖ Roles
- ❖ Attributes

Benefits

- ❖ Decentralized
- ❖ Dynamic
- ❖ Contextual
- ❖ Consolidated

Risks

- ❖ Complexity
- ❖ Confusion
- ❖ Attribute trust
- ❖ Policy trust

Prognosis: Cybersecurity

- Attributes
- Automated
- Adaptive

- Managed but not solved