The Future of Access Control: Attributes, Automation and Adaptation

Prof. Ravi Sandhu
Executive Director and Endowed Chair

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

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!
- Cyber security research and practice are loosing ground

Microsec vs Macrosec

- Most cyber security thinking is microsec
- Most big cyber security threats are macrosec

- Microsec
  - Retail attacks vs Targeted attacks
  - 99% of the attacks are thwarted by basic hygiene and some luck
  - 1% of the attacks are difficult and expensive, even impossible, to defend or detect

- Rational microsec behavior can result in highly vulnerable macrosec

Cyber Security Goal

- Enable system designers and operators to say:

  This system is secure

  Not attainable

- There is an infinite supply of low-hanging attacks

Cyber Security Goal

- Enable system designers and operators to say:

  This system is secure enough

  Many successful examples

- Mass scale, not very high assurance
  - ATM network
  - On-line banking
  - E-commerce

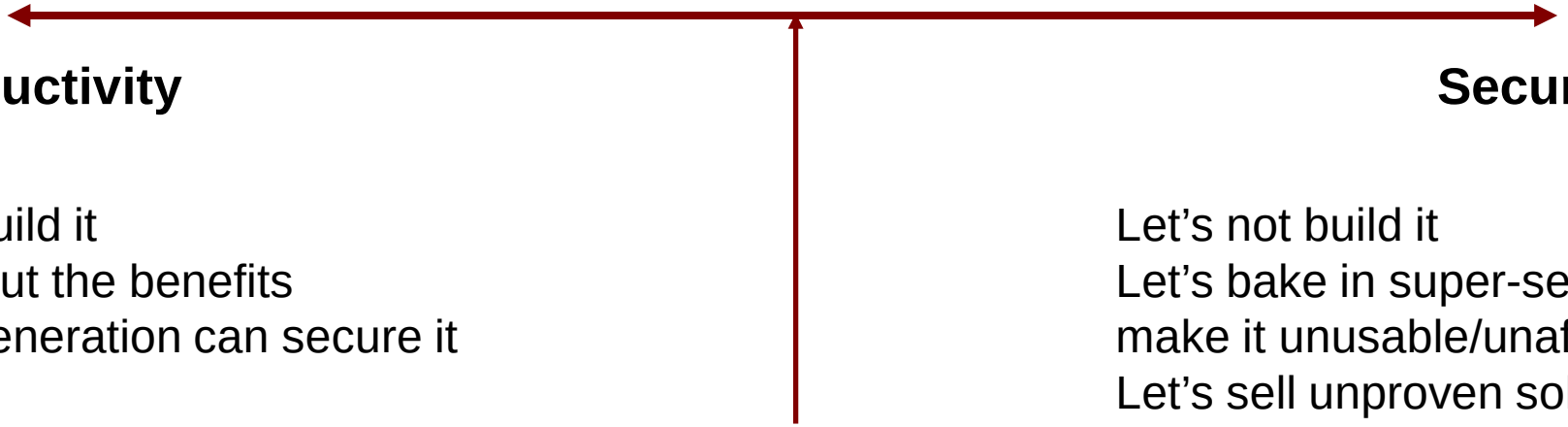
- One of a kind, extremely high assurance
  - US President's nuclear football

Cyber Security Paradox

- Our successes are not studied as success stories
- Our successes are not attainable via current cyber security science, engineering, doctrine

Cyber Security

- Cyber Security is all about
  - tradeoffs and adjustments
  - automation (in future)

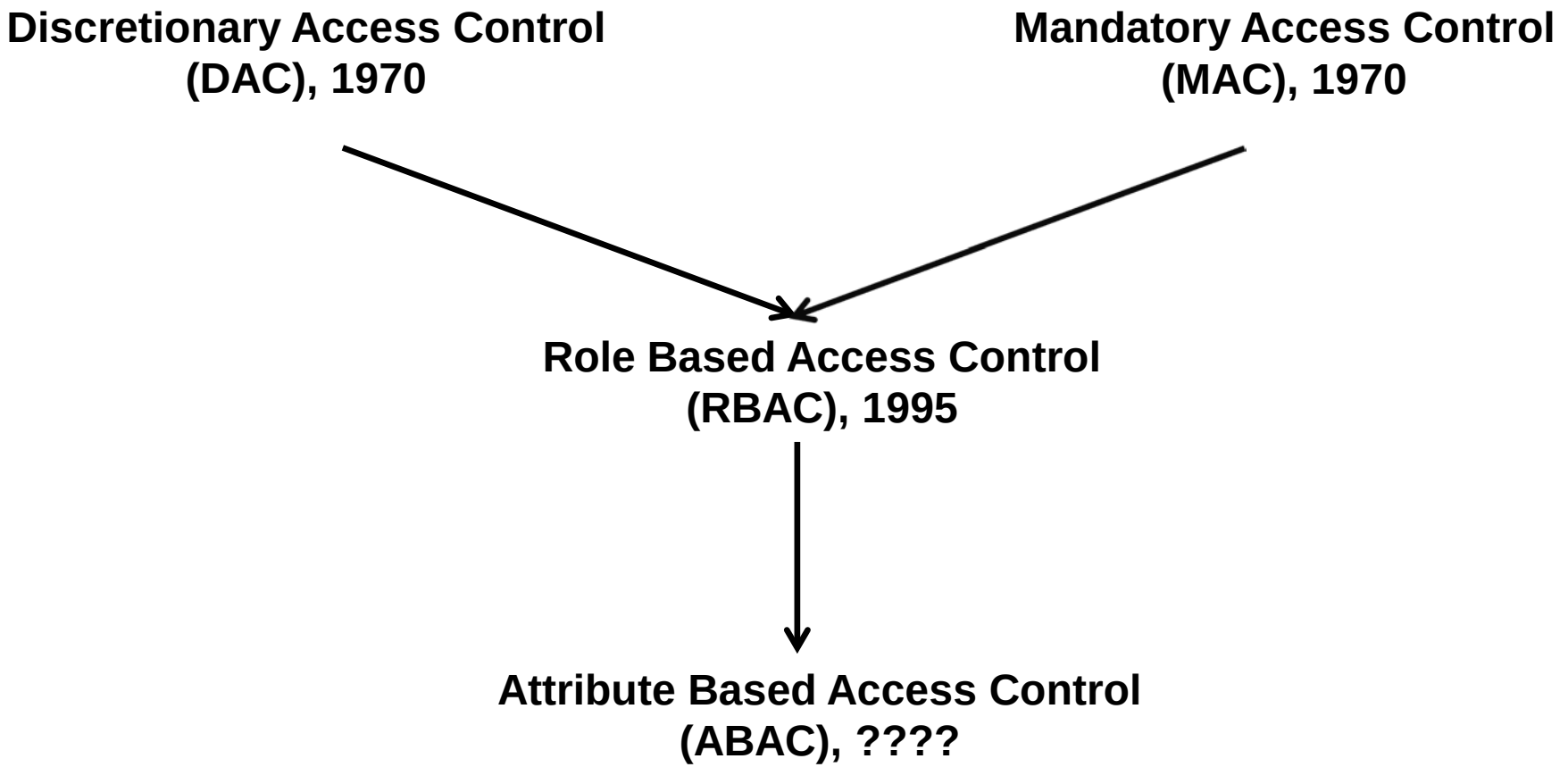


Let's build it
Cash out the benefits
Next generation can secure it

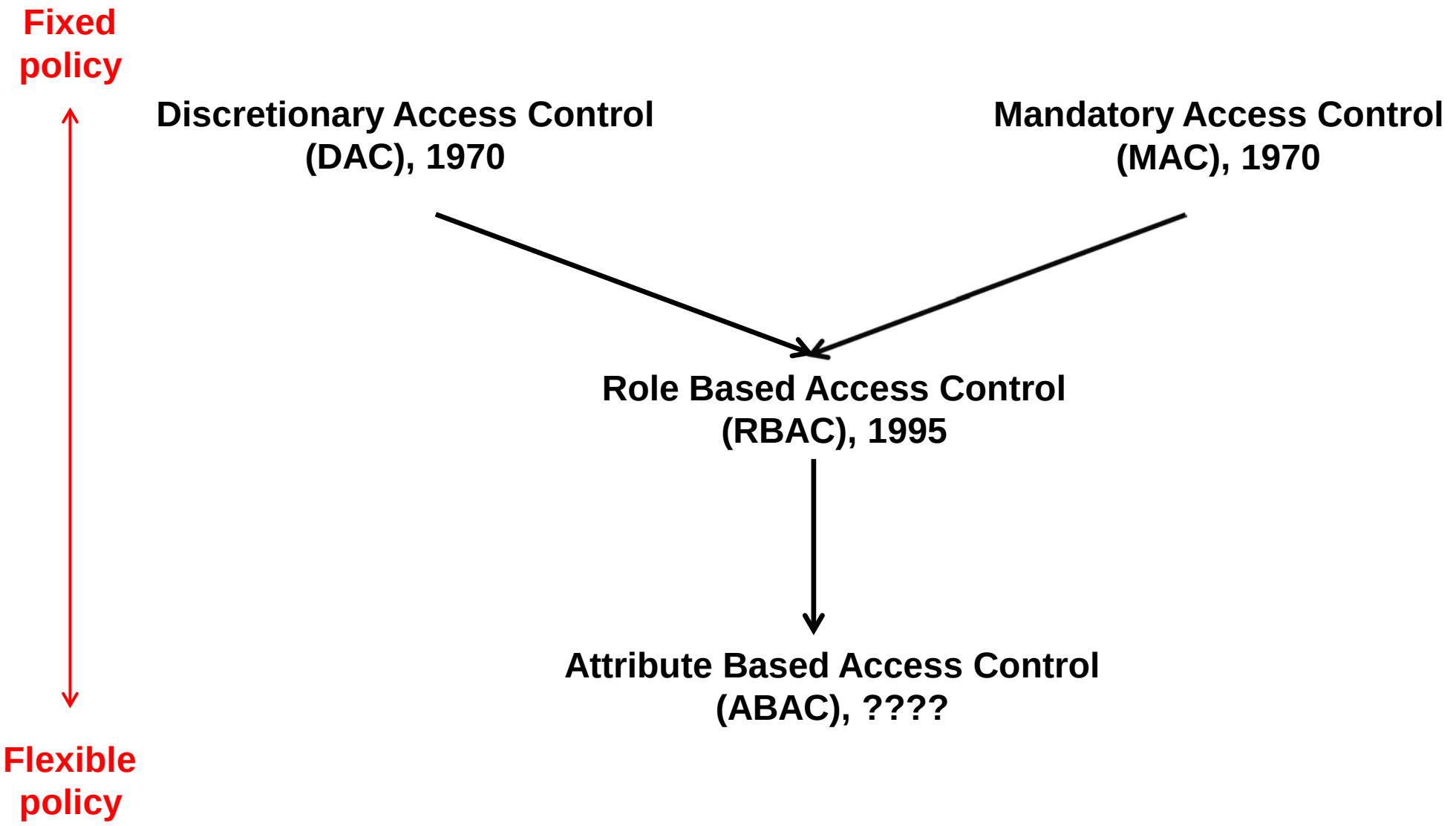
Let's not build it
Let's bake in super-security to make it unusable/unaffordable
Let's sell unproven solutions

There is a sweet spot in the middle
We don't know how to predictably find it and maintain position there

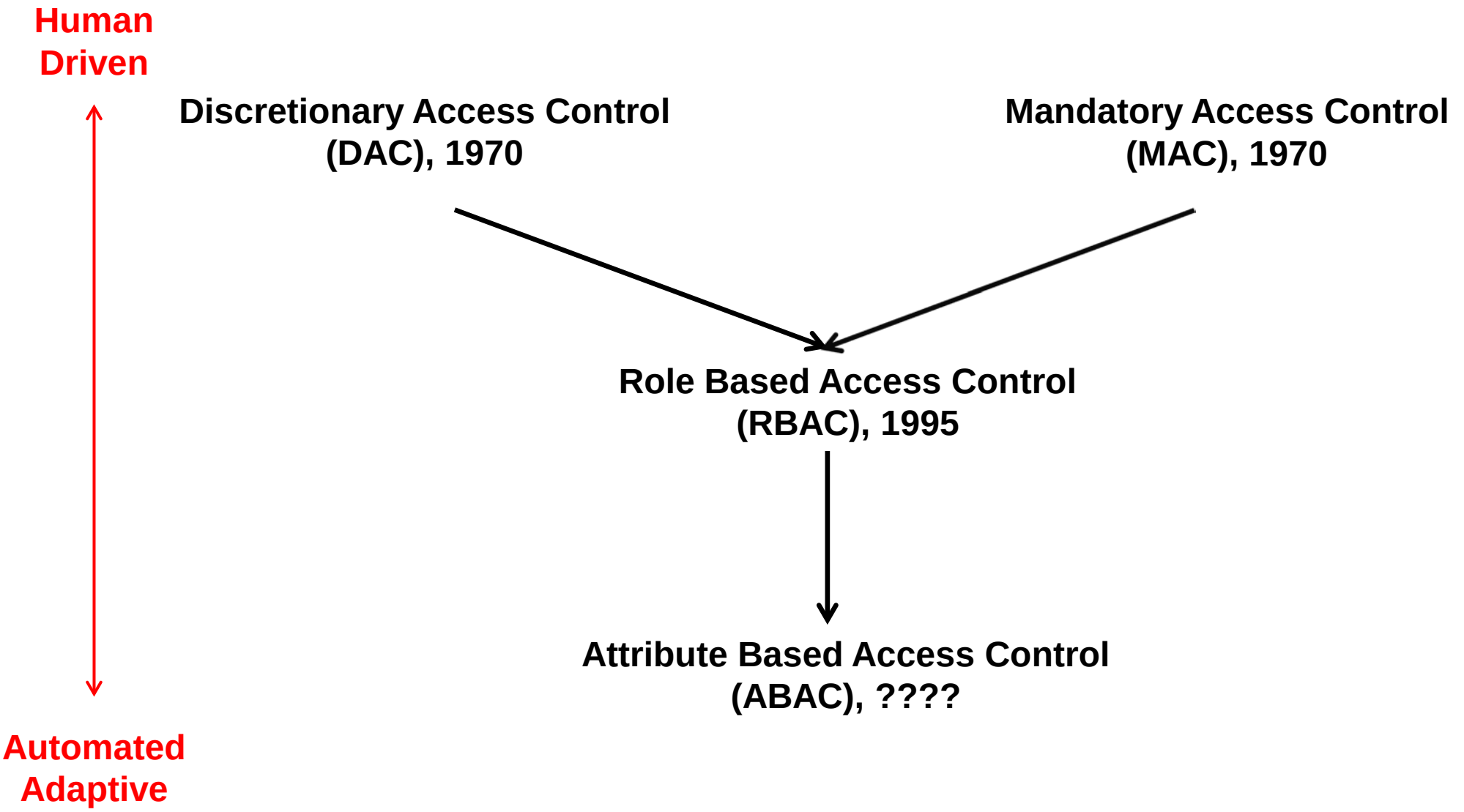
Prognosis: Access Control



Prognosis: Access Control



Prognosis: Access Control



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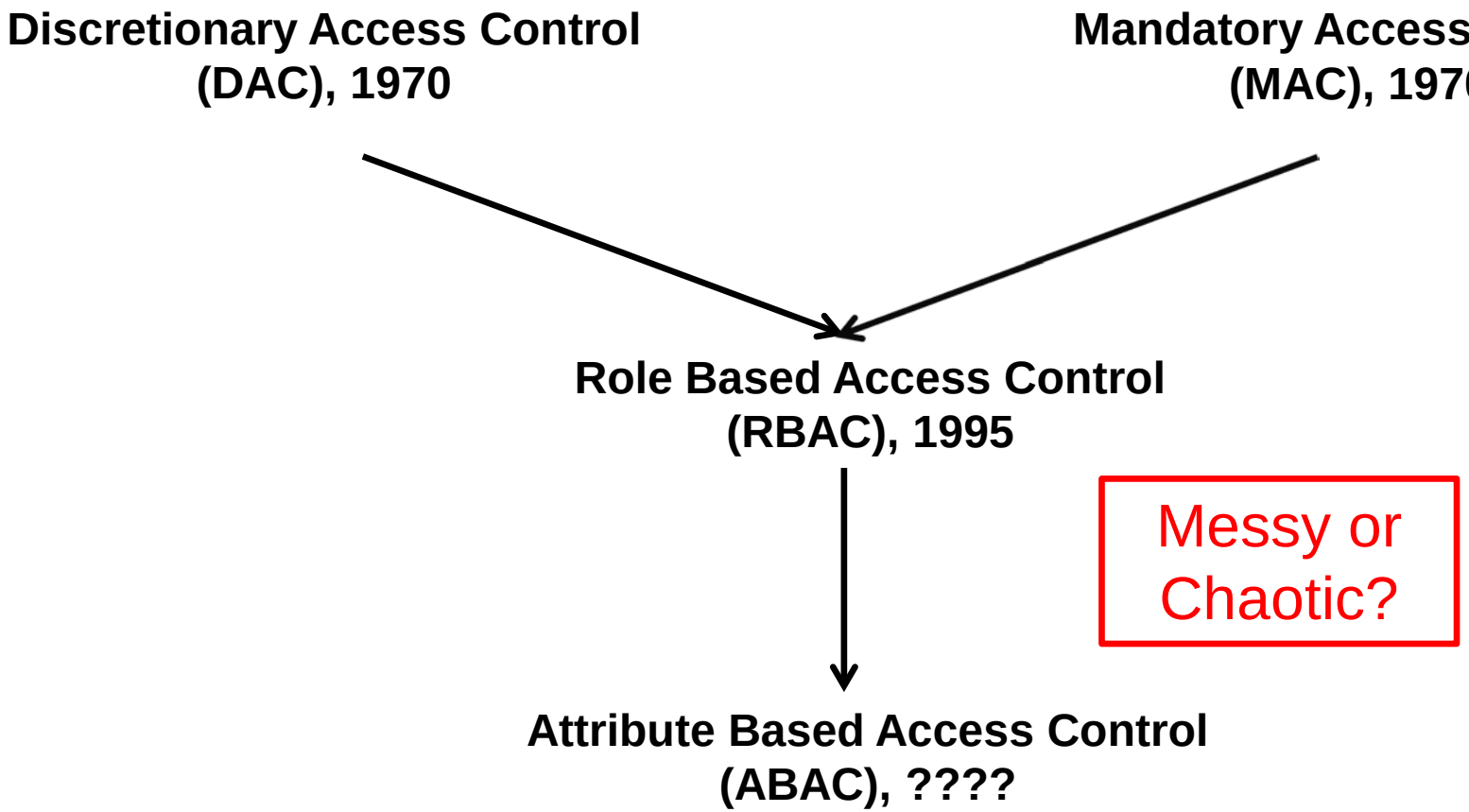
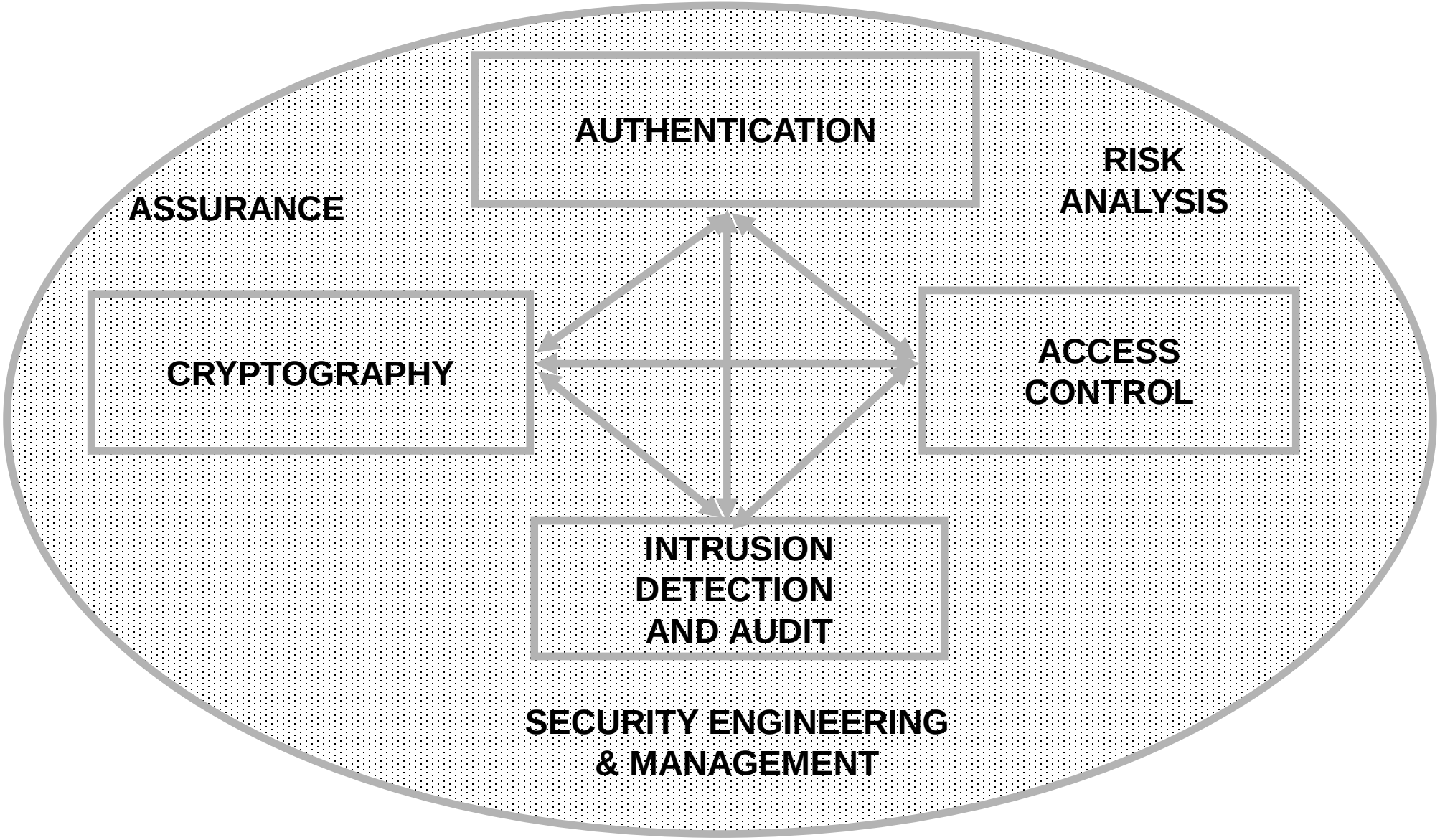


Cyber Security Technologies



World-Leading Research with Real-World Impact!

Access Control Limitations

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

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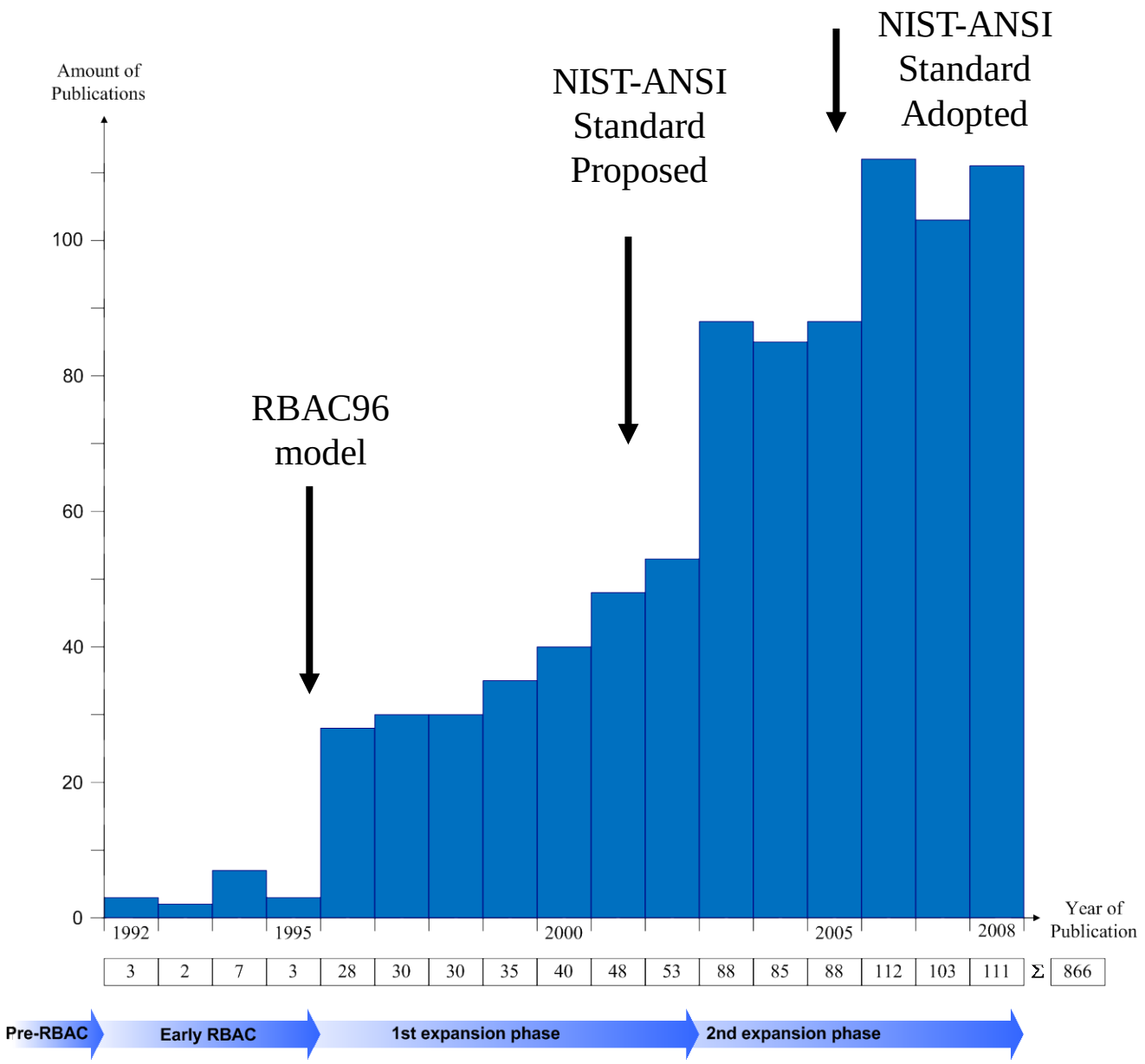
Can manage
Cannot eliminate

Access Control Models

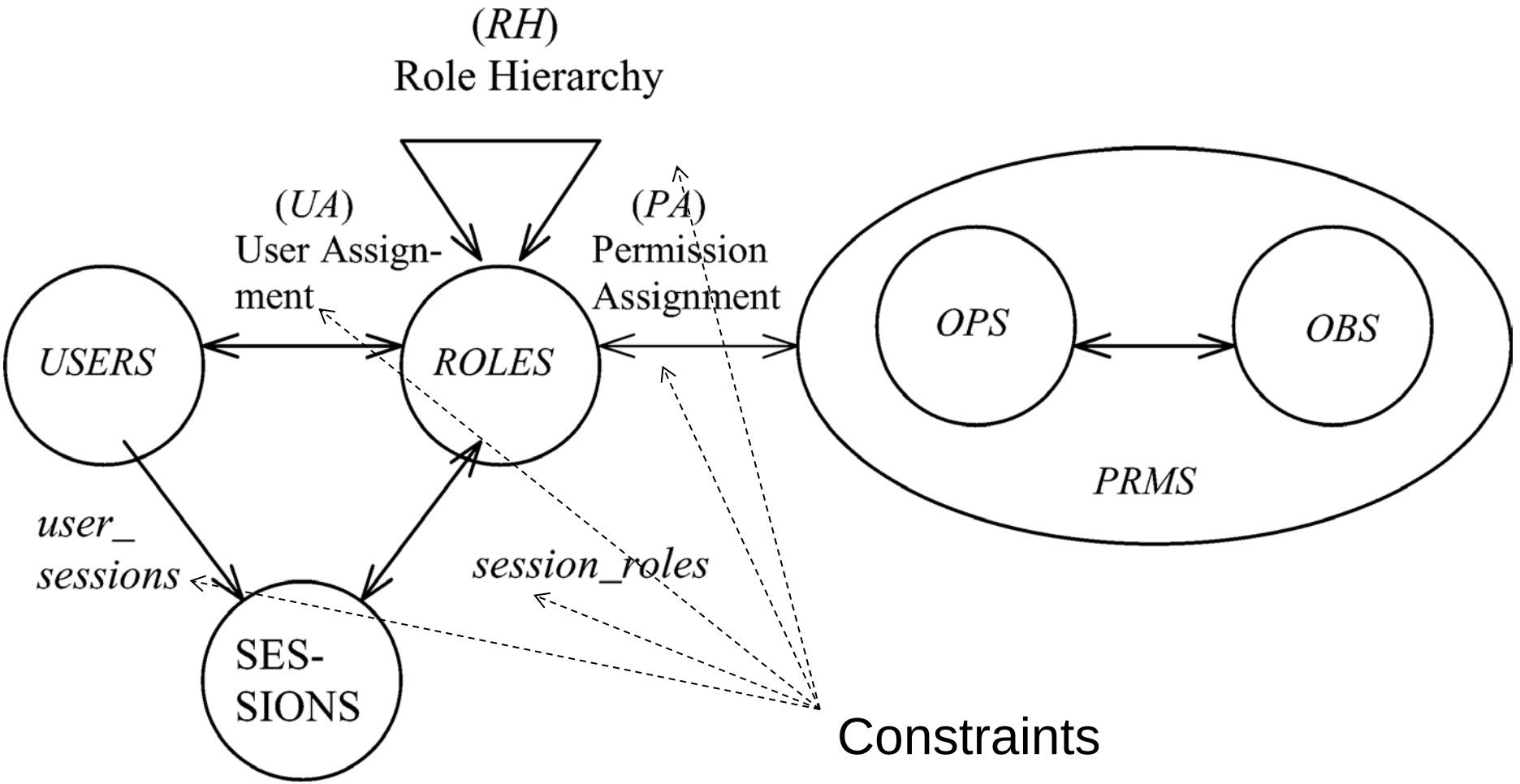
- Discretionary Access Control (DAC), 1970
  - Owner controls access
  - But only to the original, not to copies
  - Grounded in pre-computer policies of researchers
- Mandatory Access Control (MAC), 1970
  - Synonymous to Lattice-Based Access Control (LBAC)
  - Access based on security labels
  - Labels 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

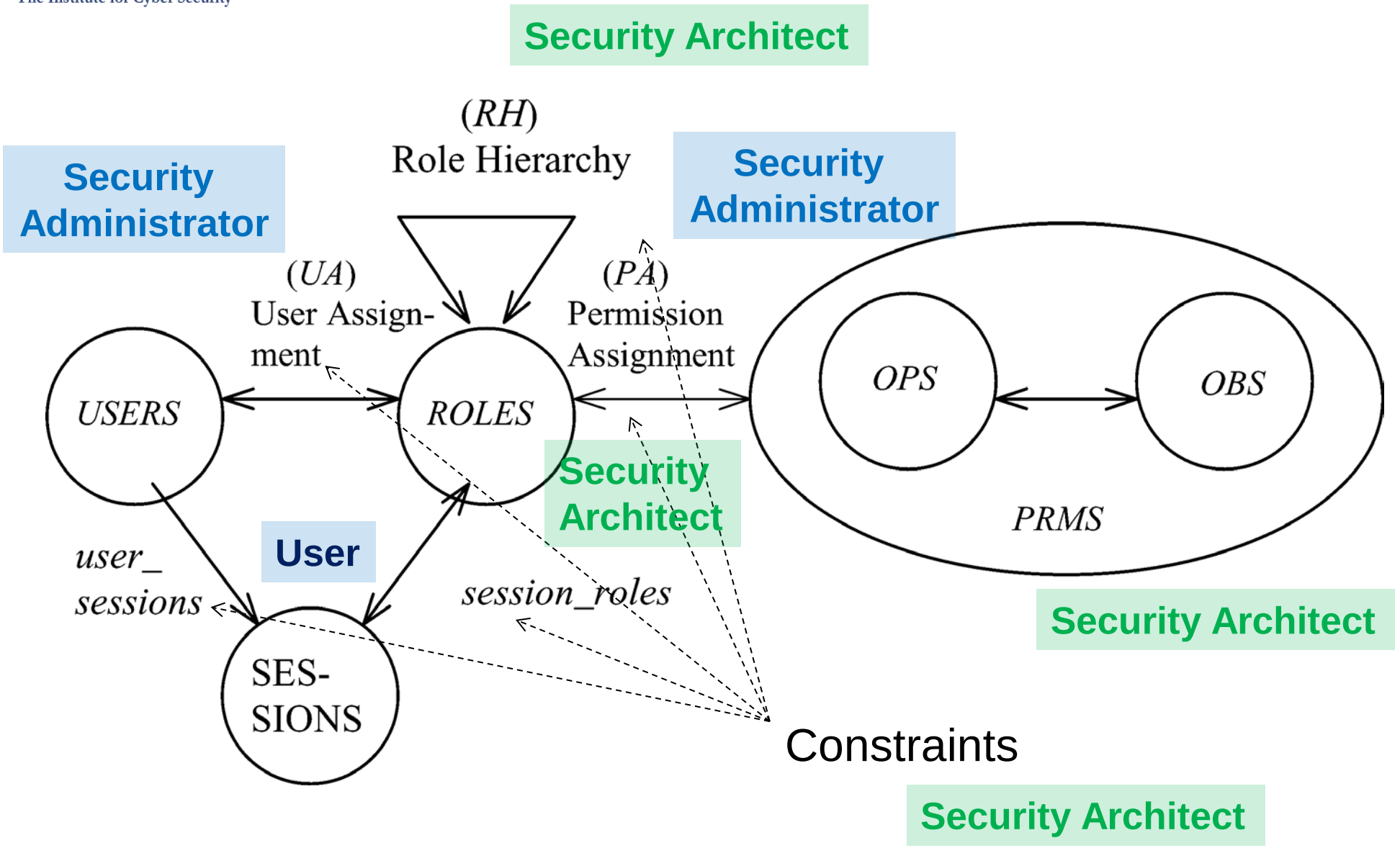
- RBAC can be configured to do MAC
- RBAC can be configured to do DAC
- RBAC is policy neutral

RBAC is neither MAC nor DAC!

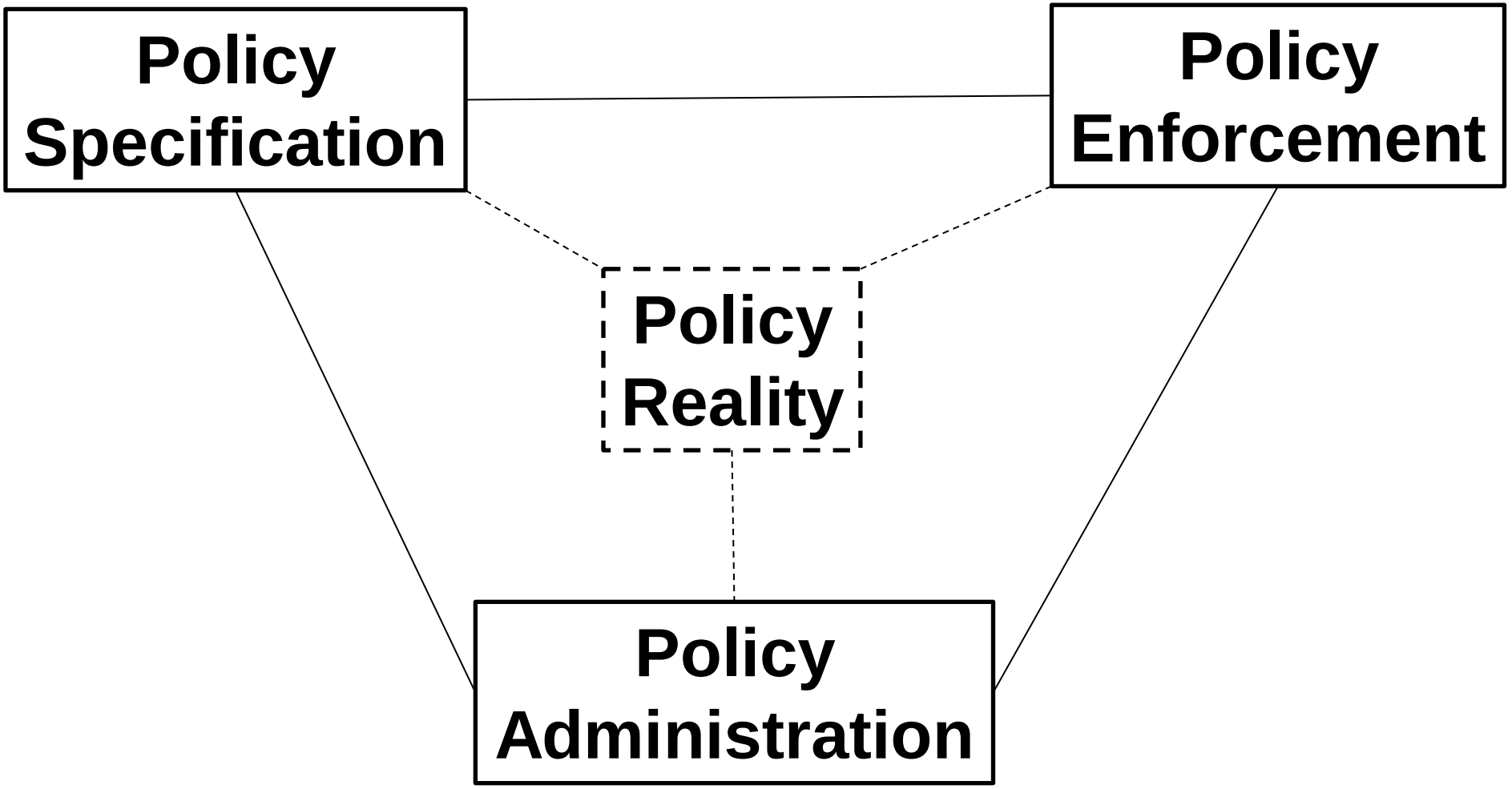
RBAC Shortcomings

- 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?

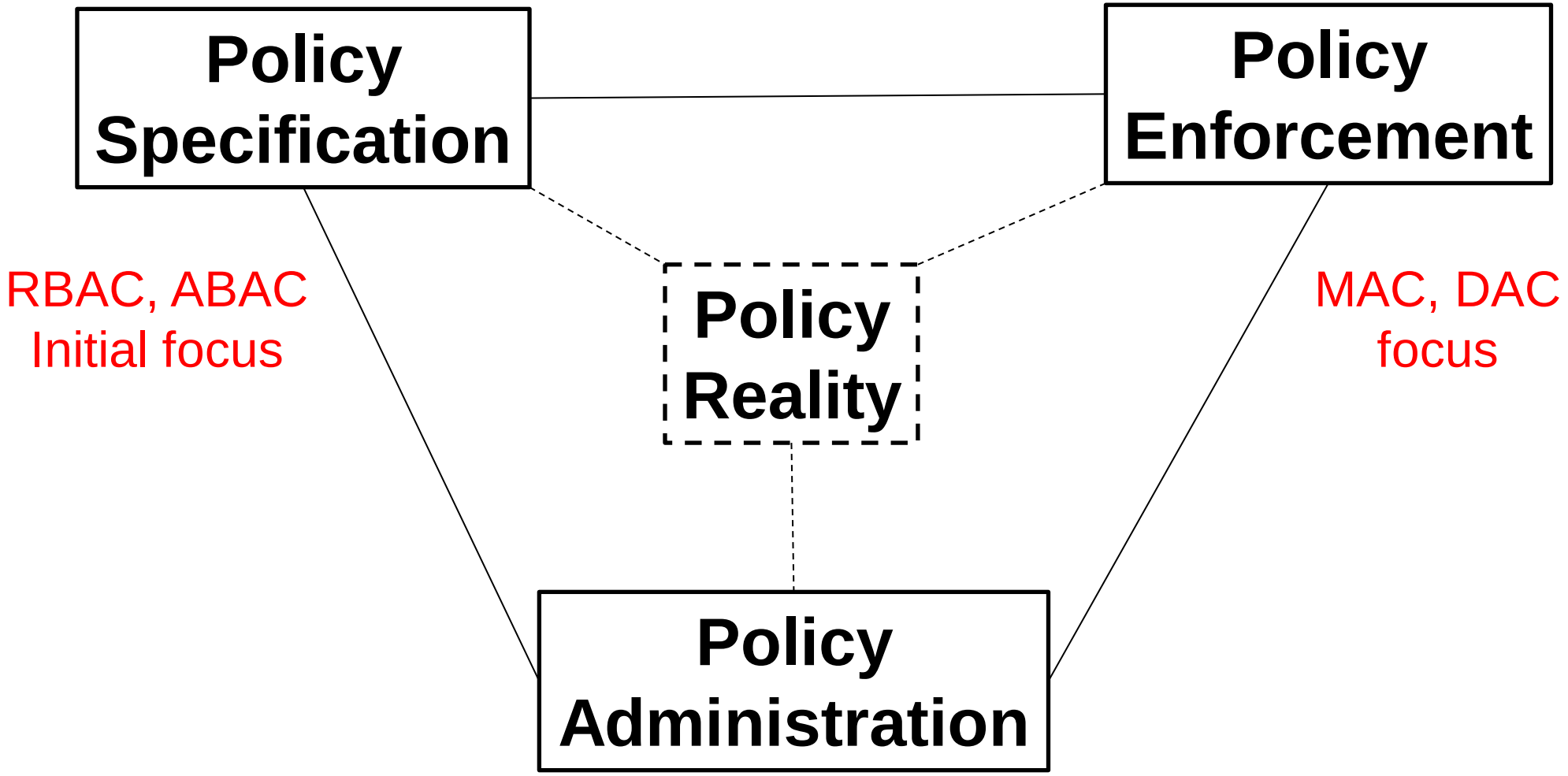
RBAC Policy Configuration Points



Access Control Models



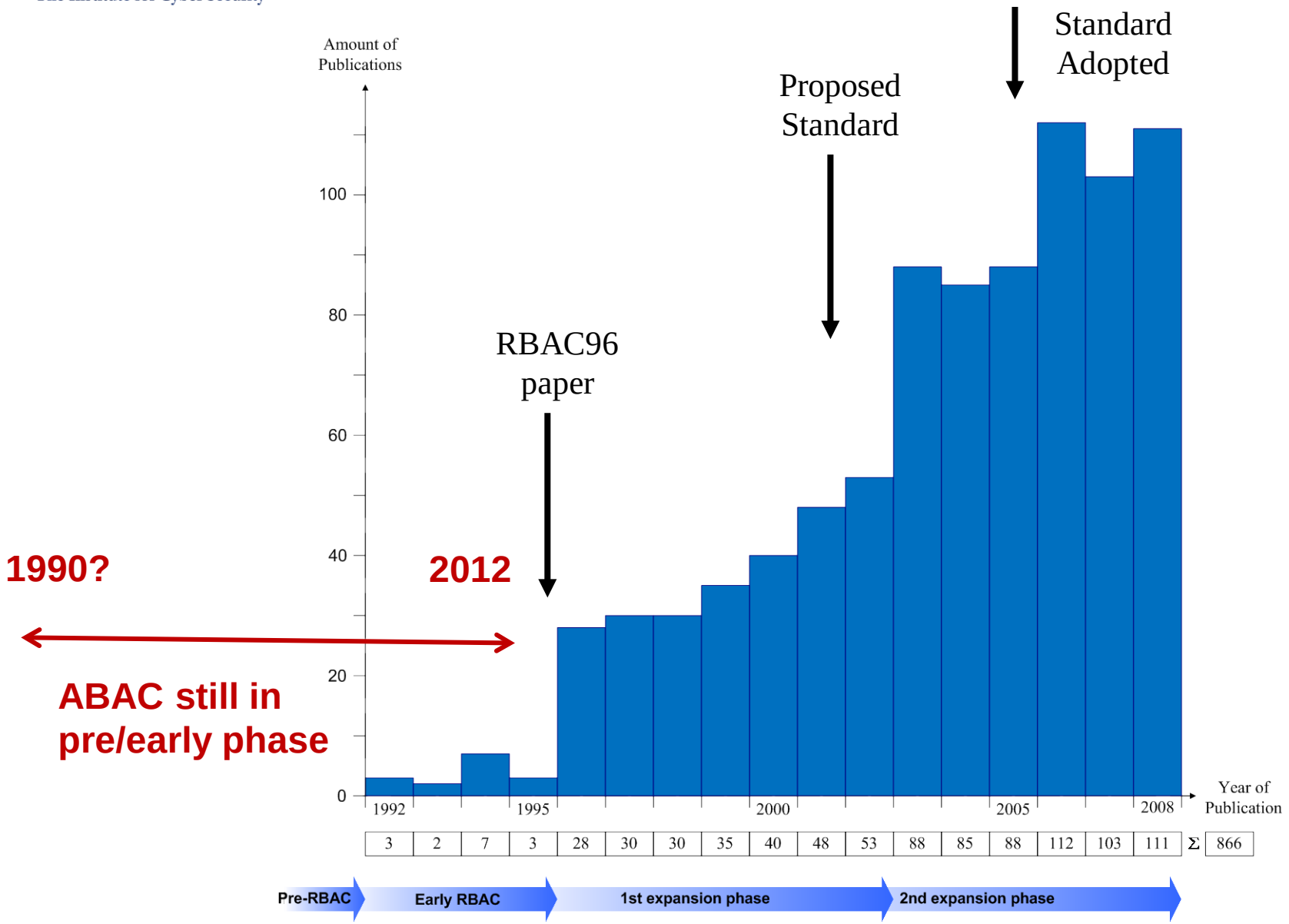
Access Control Models



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


Amount of Publications
Standard Adopted
Proposed Standard
RBAC96 paper
1990?
2012
ABAC still in pre/early phase
100
80
60
40
20
0
1992
1995
2000
2005
2008
Year of Publication
3 2 7 3 28 30 30 35 40 48 53 88 85 88 112 103 111 Σ 866
Pre-RBAC
Early RBAC
1st expansion phase
2nd expansion phase

ABAC Prior Work Includes

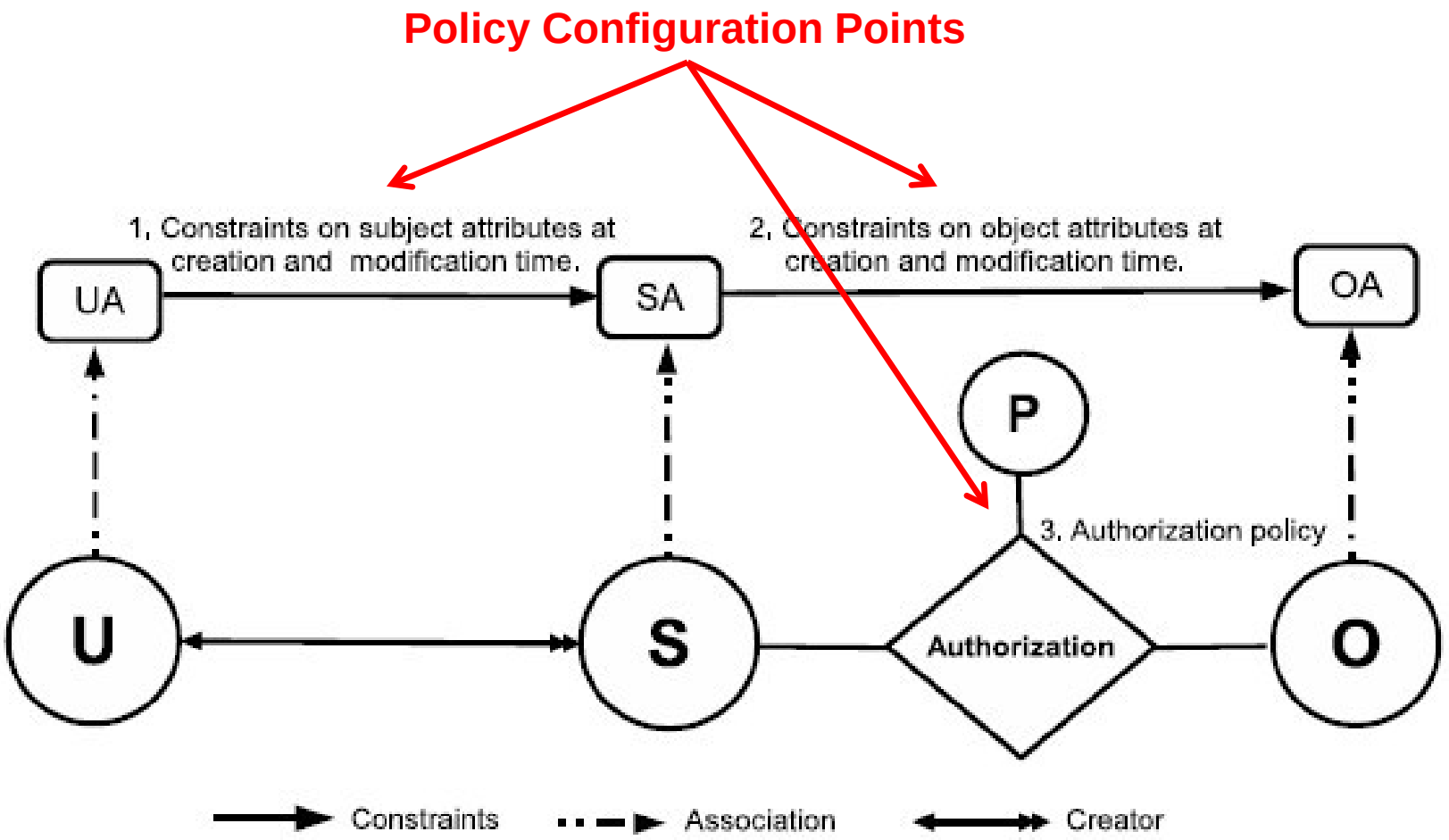
- X.509, SPKI Attribute Certificates (1999 onwards)
  - IETF RFCs and drafts
  - Tightly coupled with PKI (Public-Key Infrastructure)
- XACML (2003 onwards)
  - OASIS standard
  - Narrowly focused on particular policy combination issues
  - Fails to accommodate the ANSI-NIST RBAC standard model
  - Fails 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)

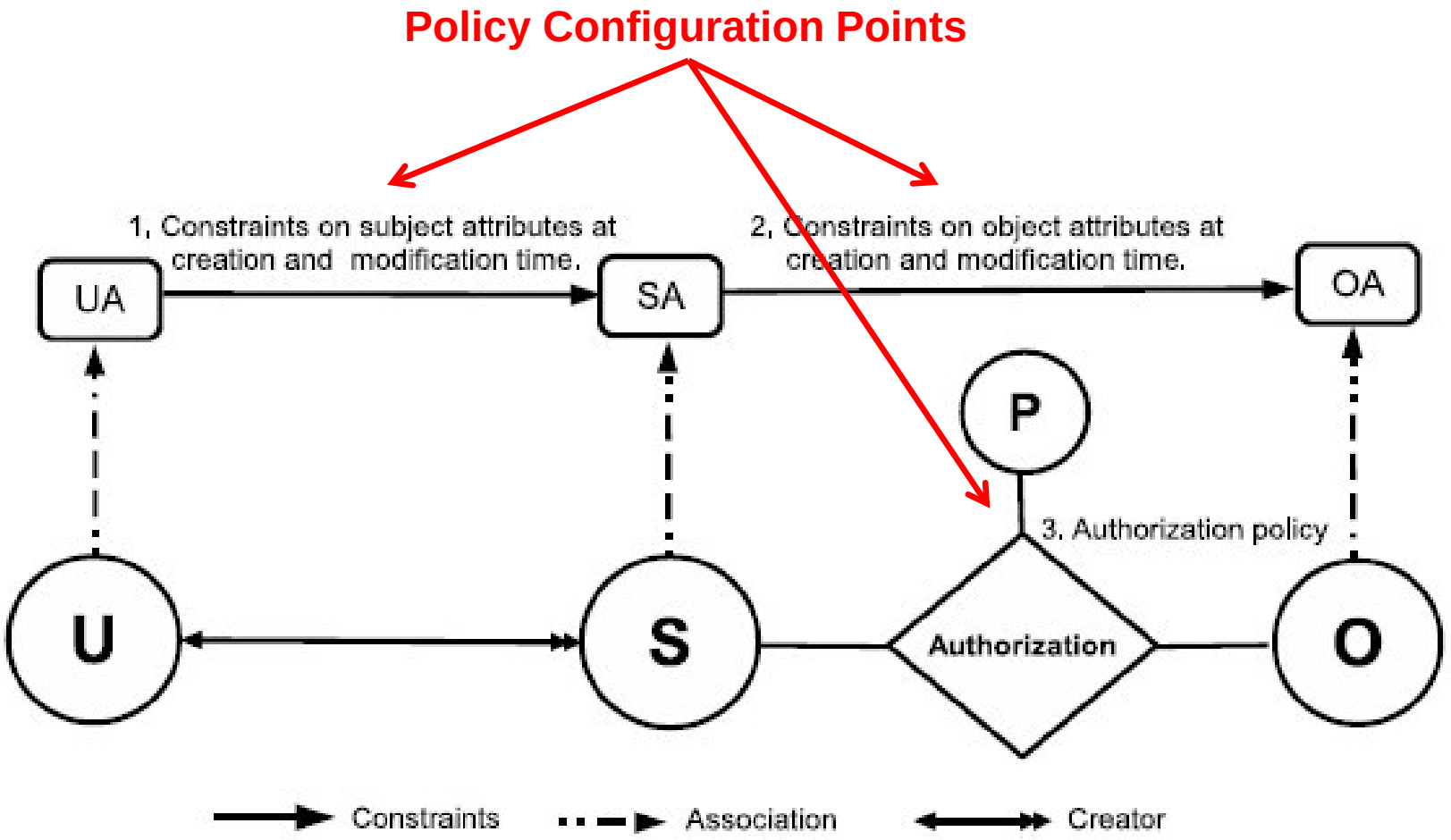
- An ABAC model requires
  - identification of policy configuration points (PCPs)
  - languages and formalisms for each PCP
- A core set of PCPs can be discovered by building the ABACα model to unify DAC, MAC and RBAC
- Additional ABAC models can then be developed by
  - increasing the sophistication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

A small but crucial step

ABACα Model Structure



ABACα Model Structure



Can be configured to do DAC, MAC, RBAC

Authorization Leap

Rights to attributes

- Rights
- Labels
- Roles
- Attributes

Messy ← ?? → **Chaotic**

Benefits

- Decentralized
- Dynamic
- Contextual
- Consolidated

Risks

- Complexity
- Confusion
- Attribute trust
- Policy trust

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- Automated
- Adaptive

- Managed but not solved

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Cyber Security Research at ICS

Applications	Technology
Secure information sharing Social networks security and privacy Secure data provenance Content delivery networks Smart grid	Cloud computing security Software defined networks Botnets
Foundations Attribute based access control Relationship based access control Malware models	