The Future of Access Control: Attributes, Automation and Adaptation

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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!
- 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

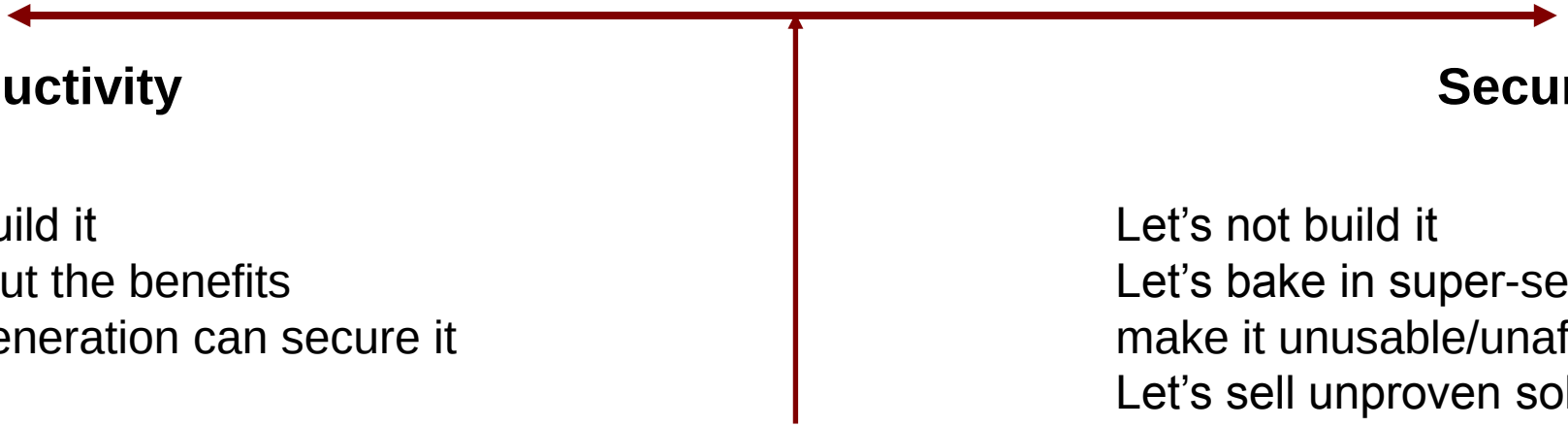
- One of a kind, extremely high assurance
  - US President's nuclear football

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)

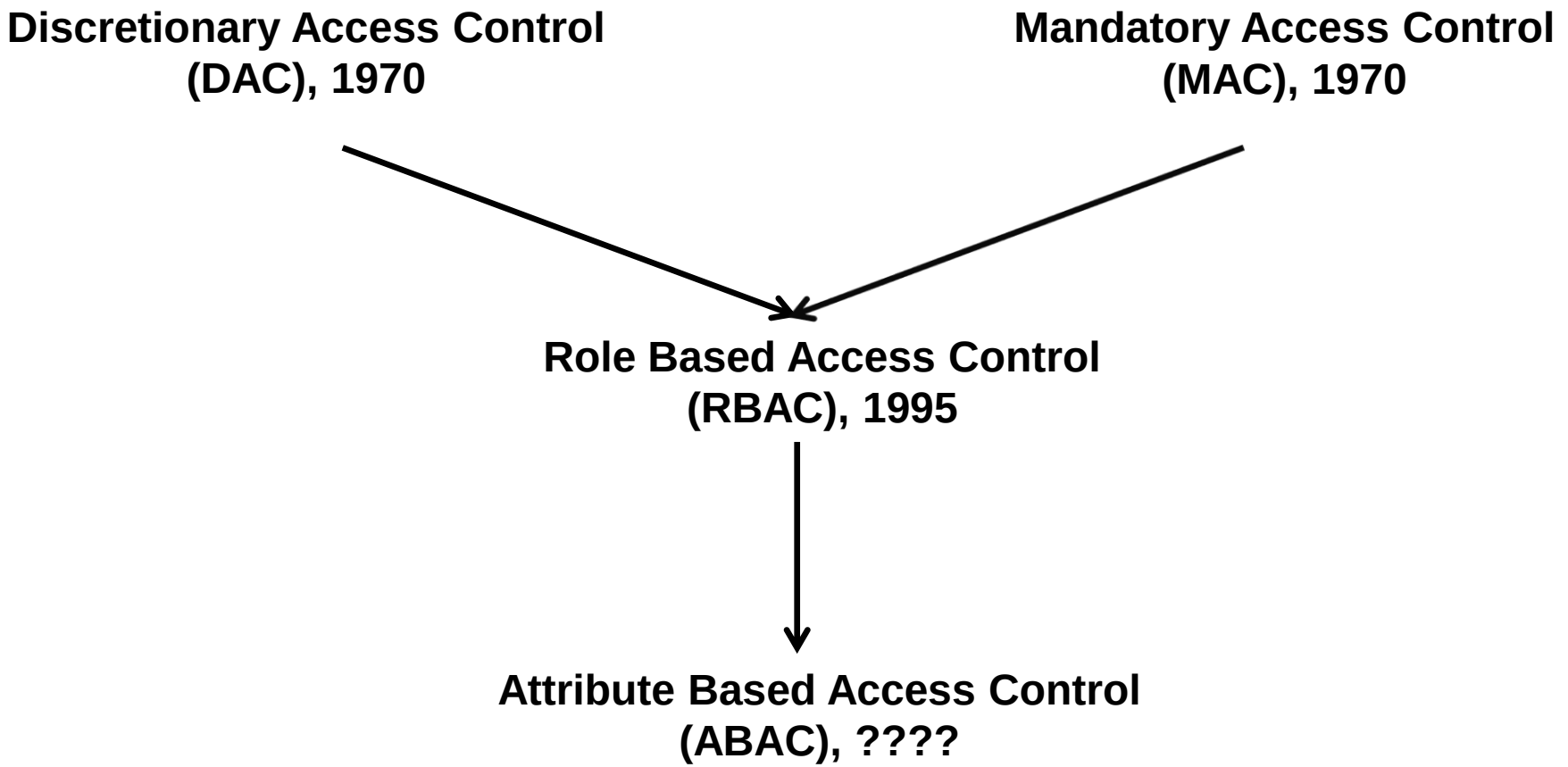


Let's build it
Cash out the benefits
Next generation can secure it

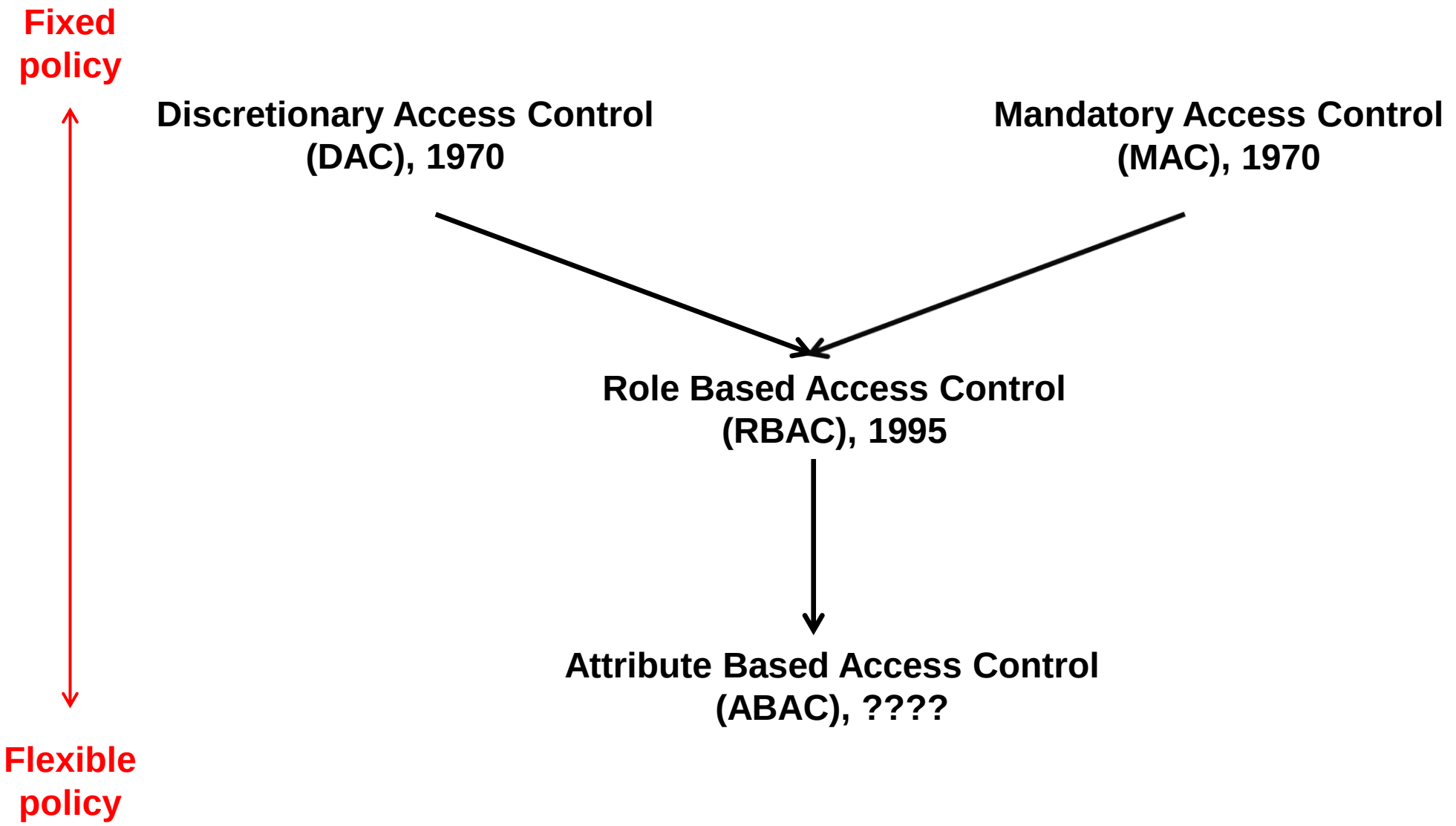
Let's not build it
Let's bake in super-security to make it unusable/unaffordable
Let's sell unproven solutions

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



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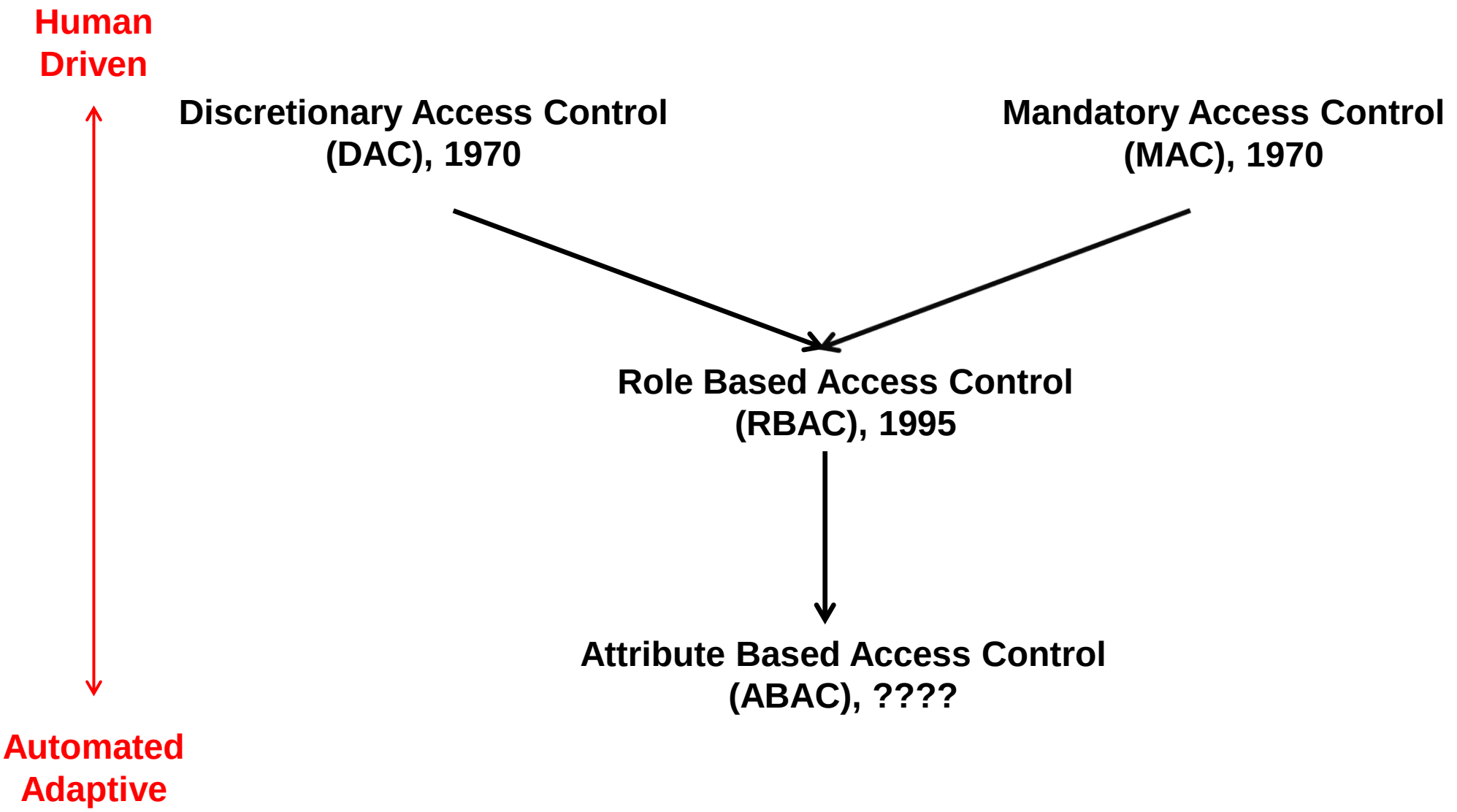

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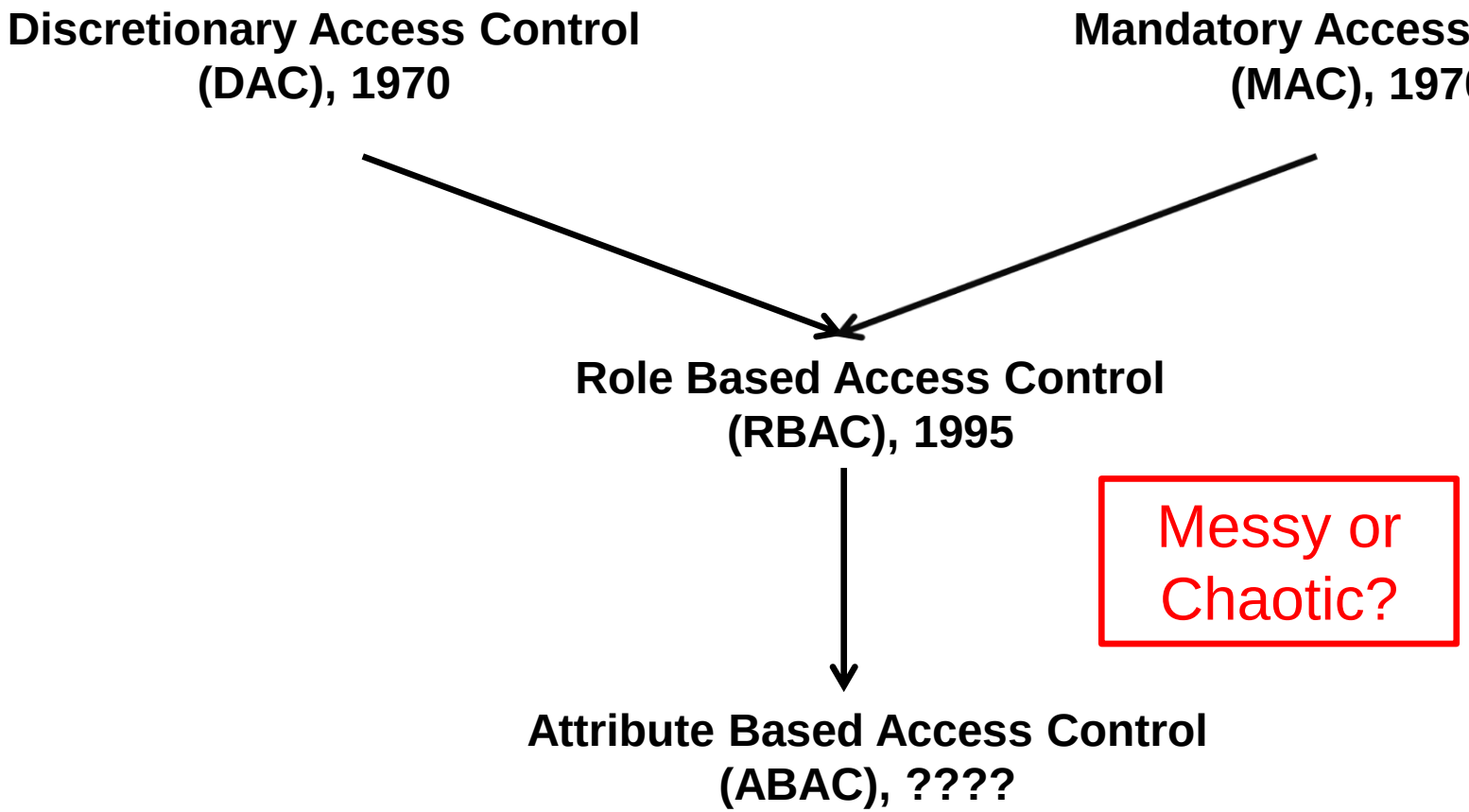
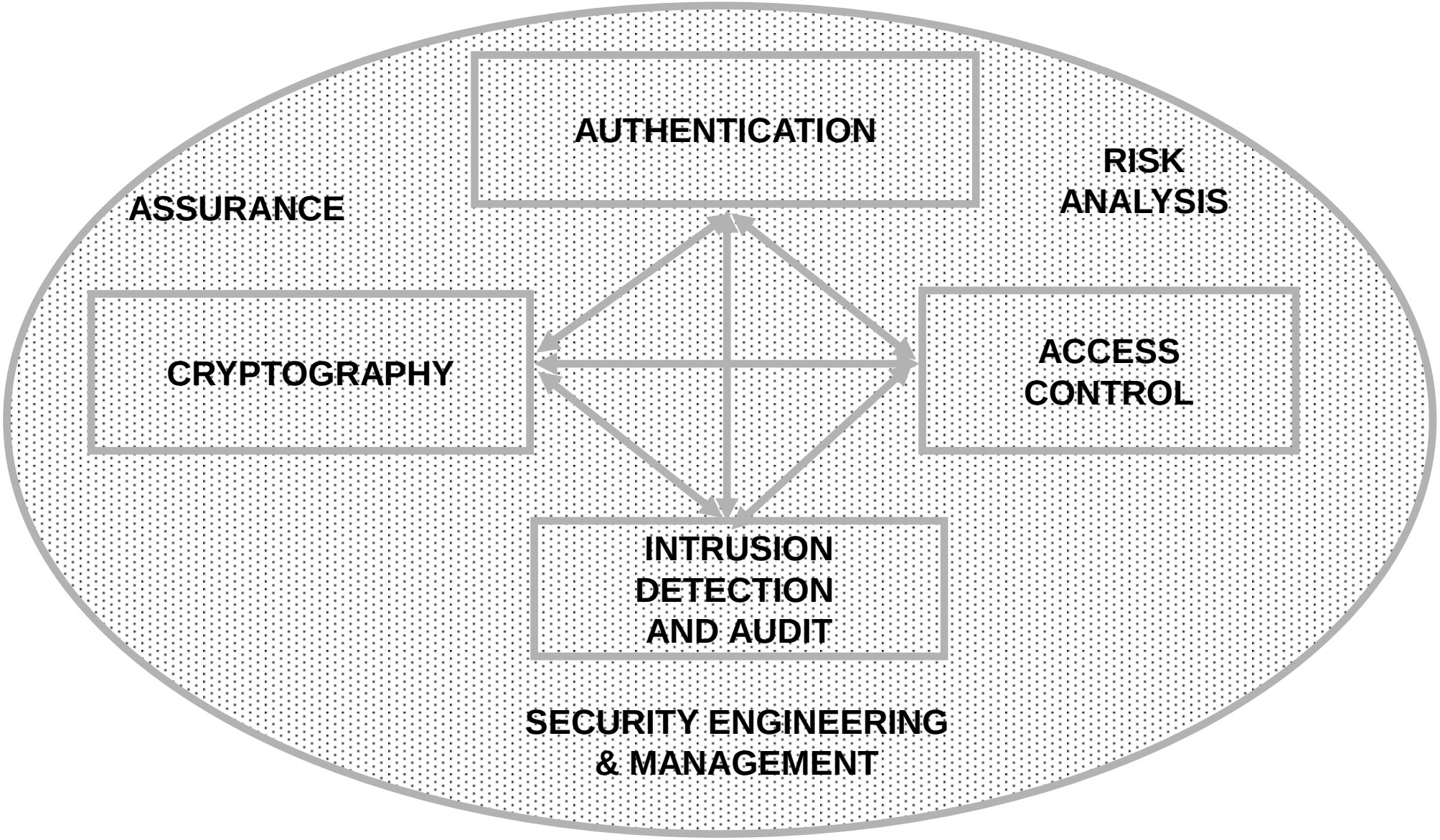


Cyber Security Technologies



Access Control Limitations

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

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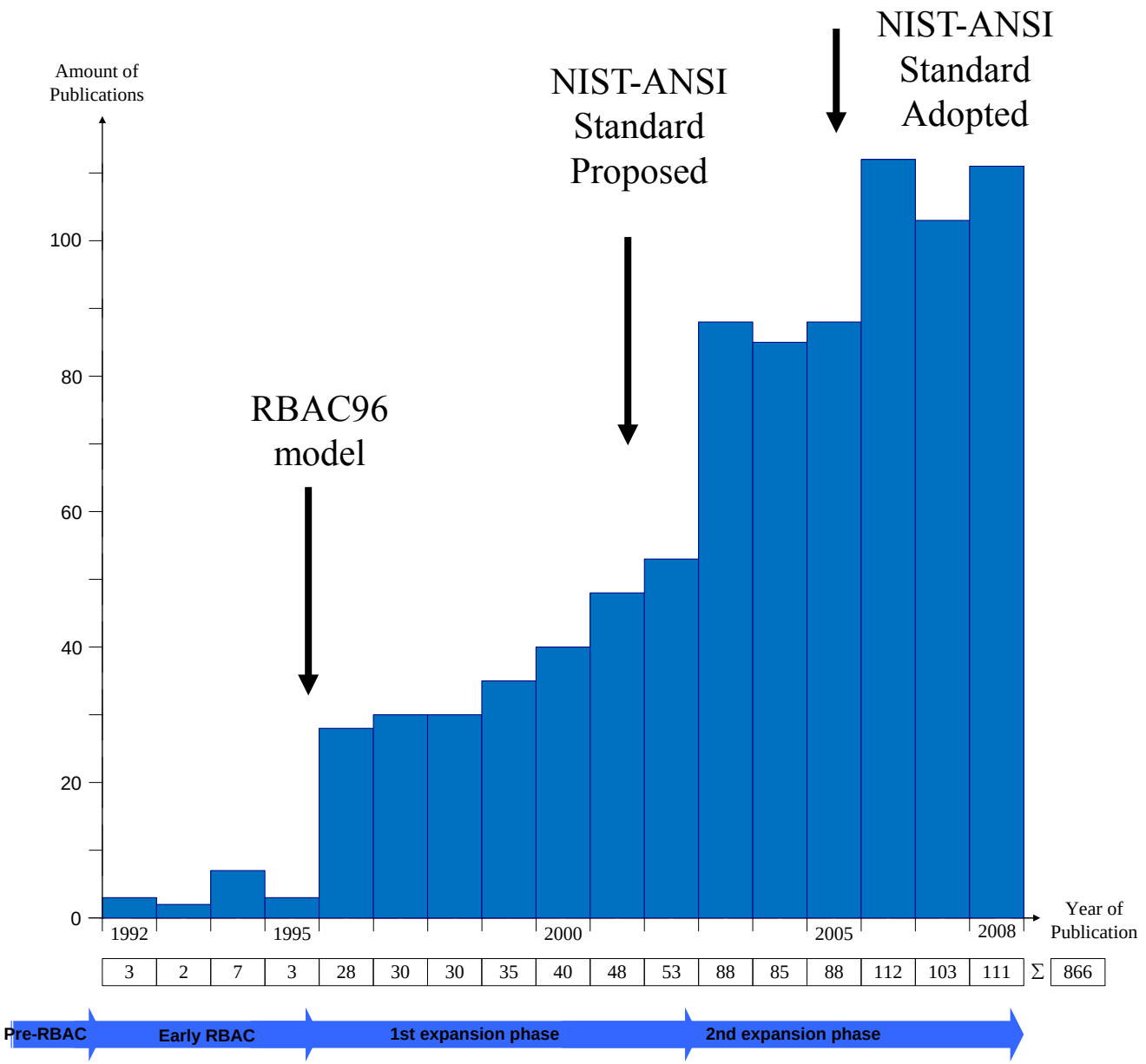
Can manage
Cannot eliminate

Access Control Models

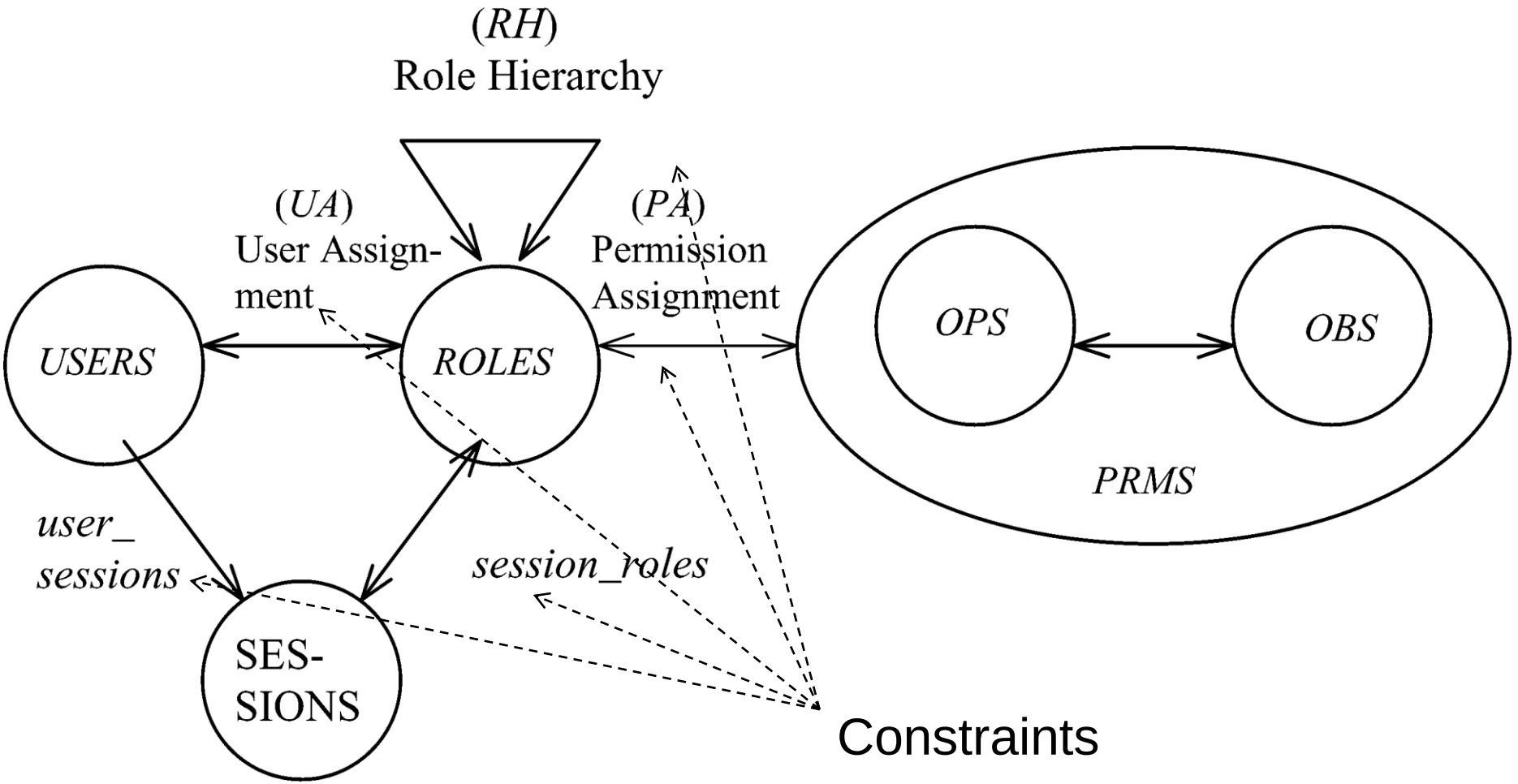
- Discretionary Access Control (DAC), 1970
  - Owner controls access
  - But only to the original, not to copies
  - Grounded in pre-computer policies of researchers
- Mandatory Access Control (MAC), 1970
  - Synonymous to Lattice-Based Access Control (LBAC)
  - Access based on security labels
  - Labels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

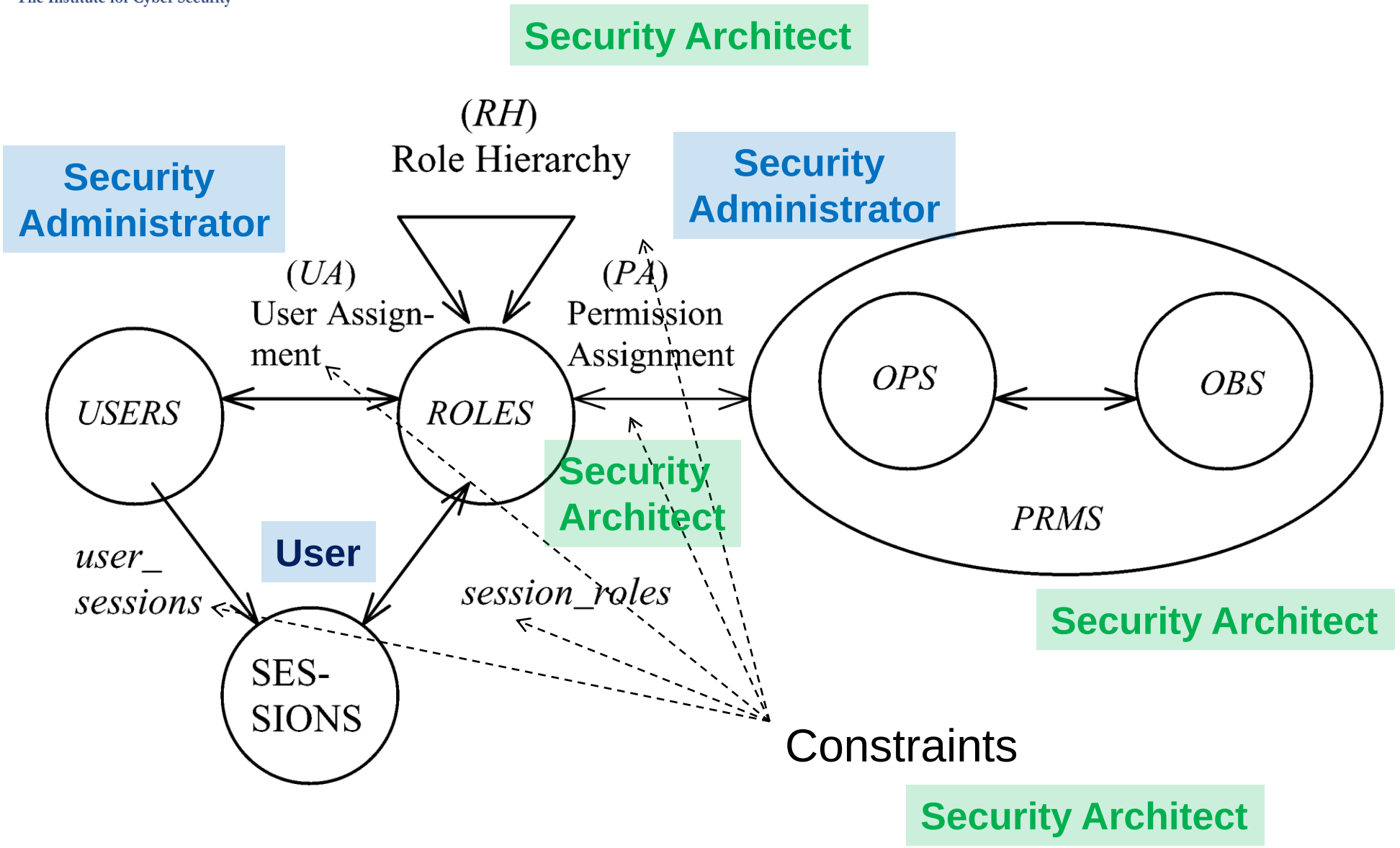
- RBAC can be configured to do MAC
- RBAC can be configured to do DAC
- RBAC is policy neutral

RBAC is neither MAC nor DAC!

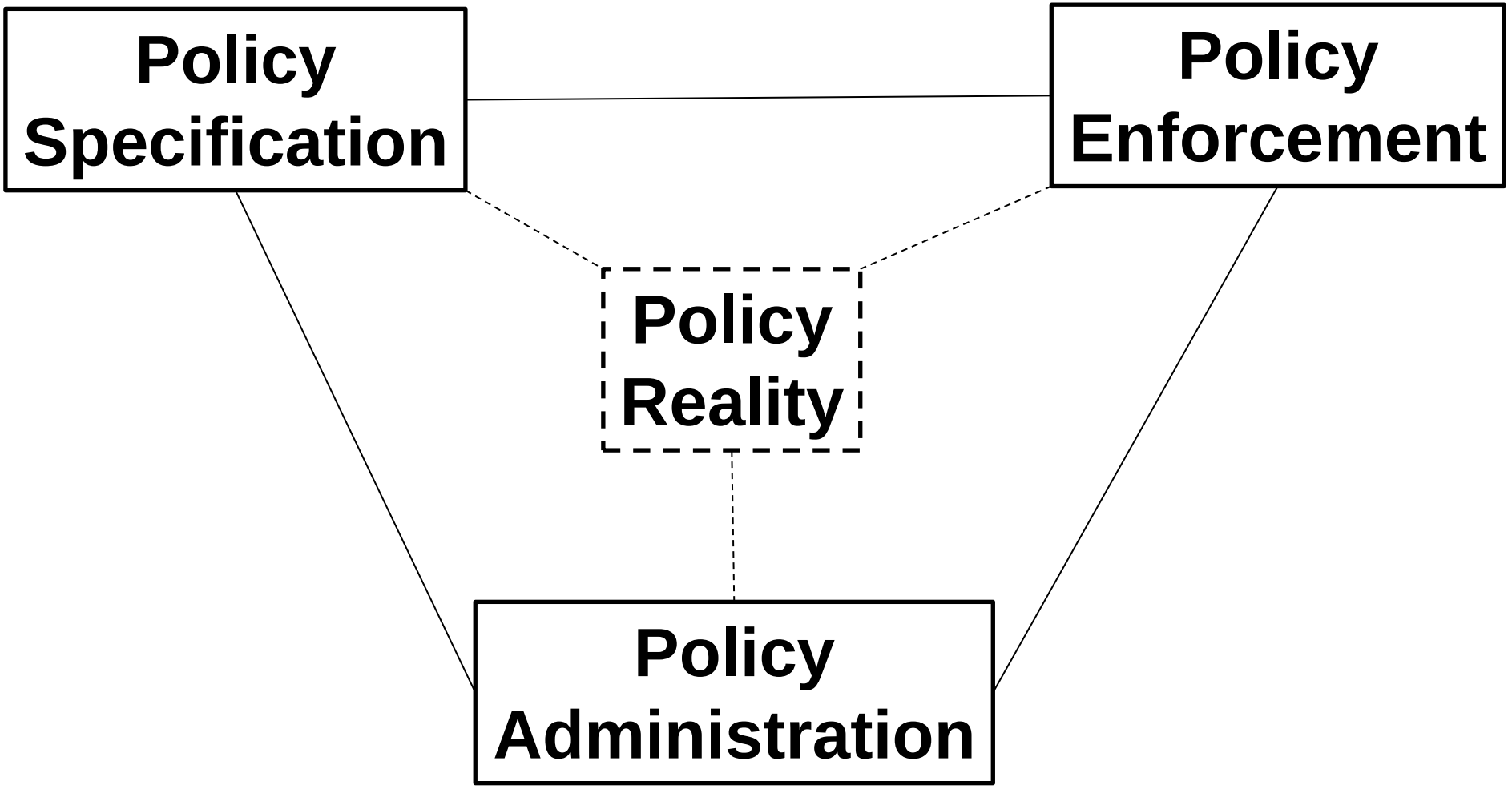
RBAC Shortcomings

- 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?

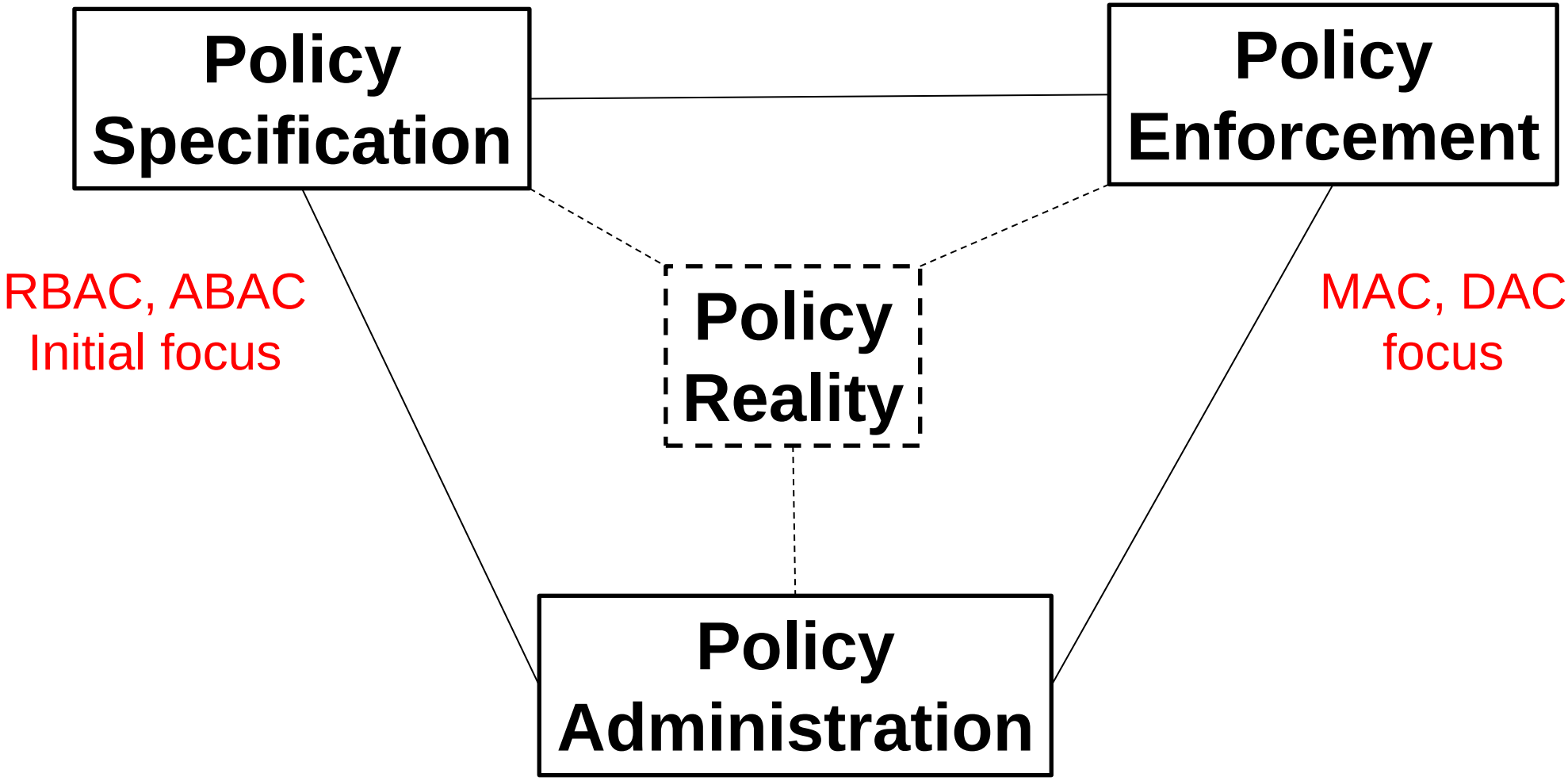
RBAC Policy Configuration Points



Access Control Models



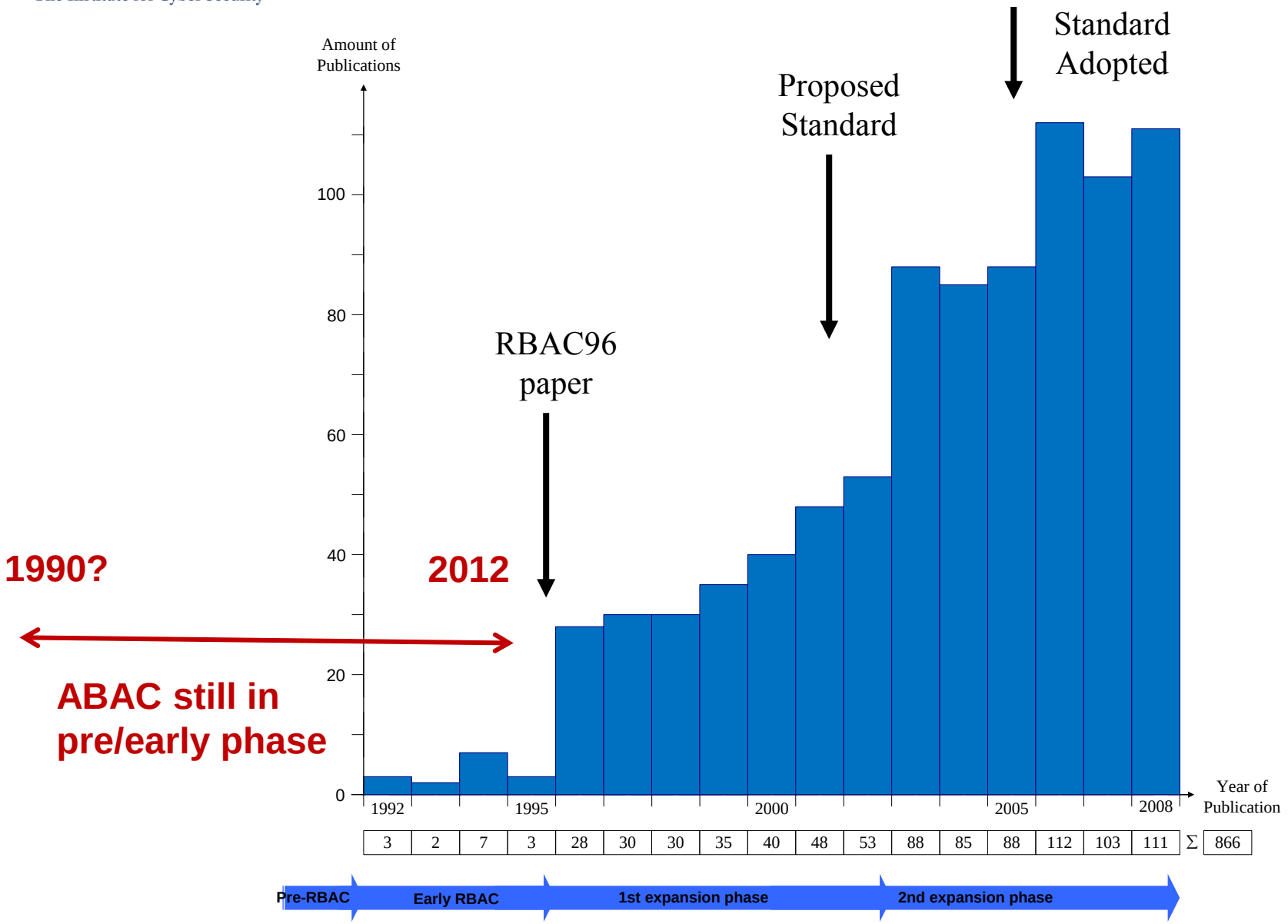
Access Control Models



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

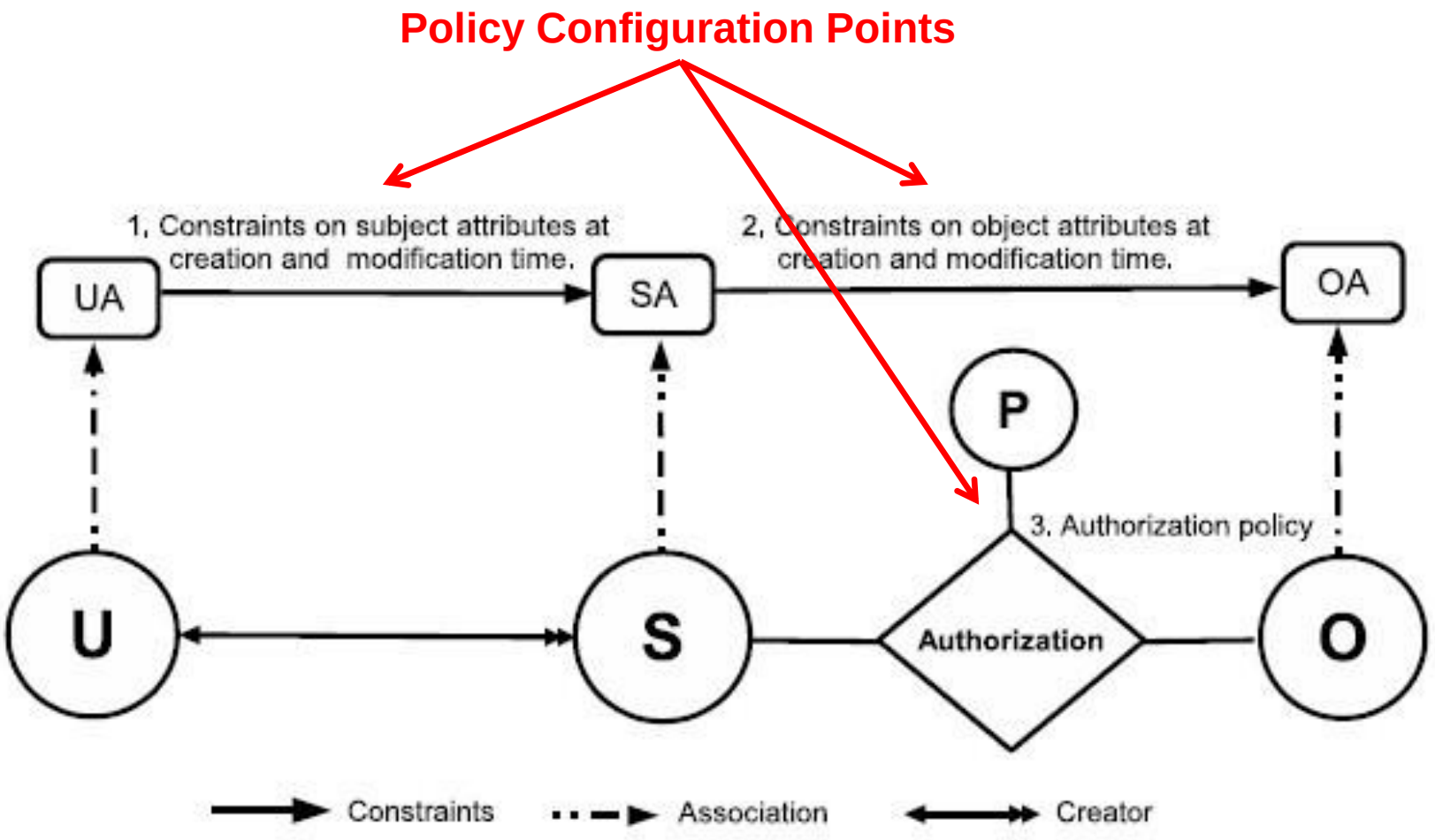
- X.509, SPKI Attribute Certificates (1999 onwards)
  - IETF RFCs and drafts
  - Tightly coupled with PKI (Public-Key Infrastructure)
- XACML (2003 onwards)
  - OASIS standard
  - Narrowly focused on particular policy combination issues
  - Fails to accommodate the ANSI-NIST RBAC standard model
  - Fails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

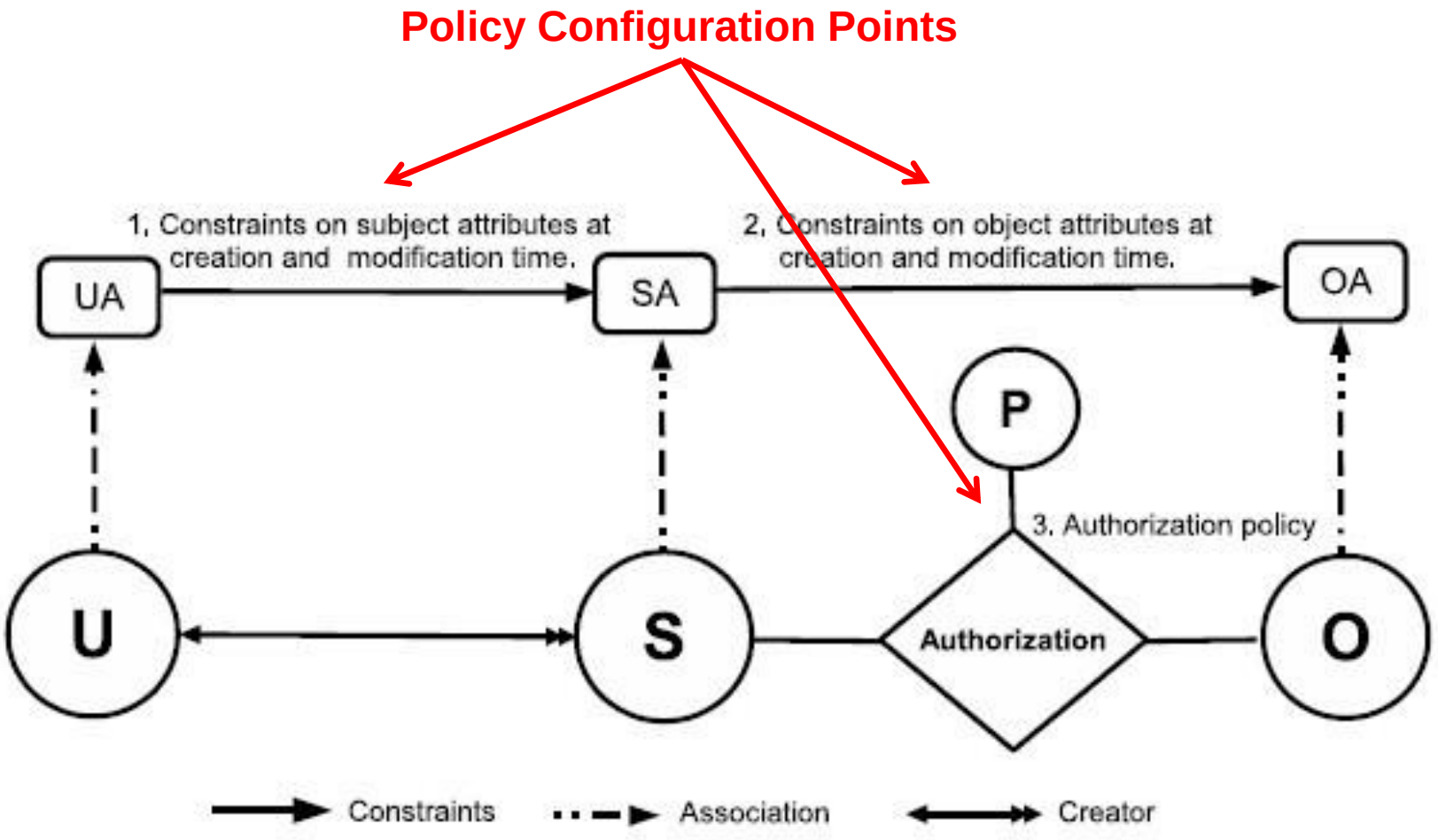
- An ABAC model requires
  - identification of policy configuration points (PCPs)
  - languages and formalisms for each PCP
- A core set of PCPs can be discovered by building the ABACα model to unify DAC, MAC and RBAC
- Additional ABAC models can then be developed by
  - increasing the sophistication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

A small but crucial step

ABACα Model Structure

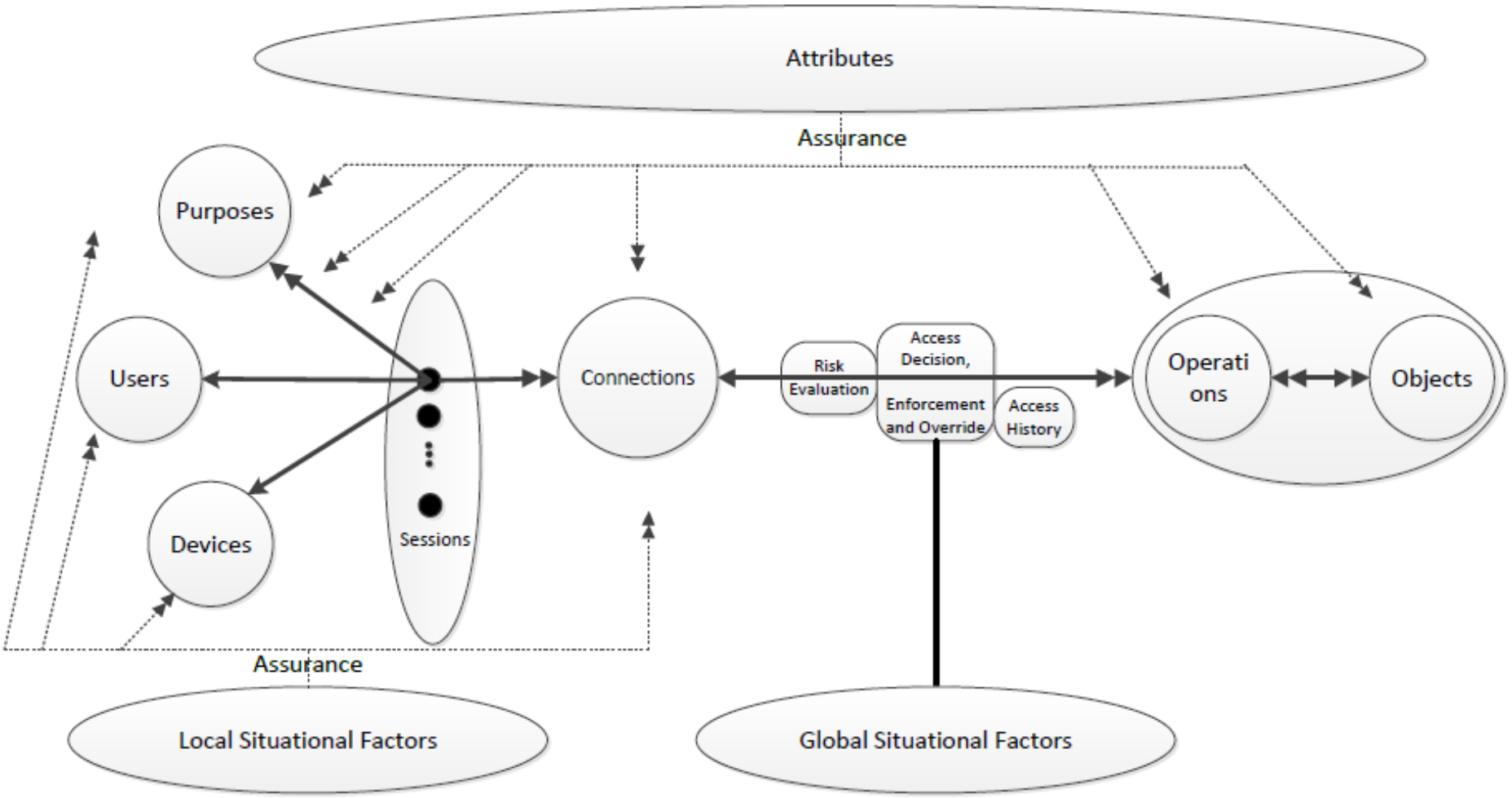


ABACα Model Structure



Can be configured to do DAC, MAC, RBAC

Risk Adaptive Access Control (RAdAC)



Authorization Leap

Rights to attributes

- Rights
- Labels
- Roles
- Attributes

Messy ← ?? → **Chaotic**

Benefits

- Decentralized
- Dynamic
- Contextual
- Consolidated

Risks

- Complexity
- Confusion
- Attribute trust
- Policy trust

Prognosis: Cyber Security

- Attributes
- Automated
- Adaptive

- Managed but not solved