Mobile Agent Security

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Agenda

- Security requirements
- Trusted third party
  - Multi-jump security
  - Trusted source
  - Itinerary assurance
- Encrypted computing
- Signed code
- Authentication
- Hightened need for traditional security (time permitting)

New Security Requirements

- Mobile agents arrive and begin executing
  - Without interaction from user
- With MAs, an attacker might insert unsafe code to be executed, with unsafe data, at any time
  - With traditional distributed computing, an attacker can execute known safe code with bad data, perhaps at a bad time

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Security Needs

- Exchange mobile agents with untrusted hosts
  - Framework must not facilitate an attack
- Ensure unsafe code does not attack
  - Even if mobile agent has passed through a hostile host
- Also requires traditional distributed security

Security Needs *(continued)*

- Protect MA from hostile host
  - Termination
    - Might not be desirable
  - Modification
  - Correct execution
- Protect host from hostile MA
  - Resources
  - Data
  - User

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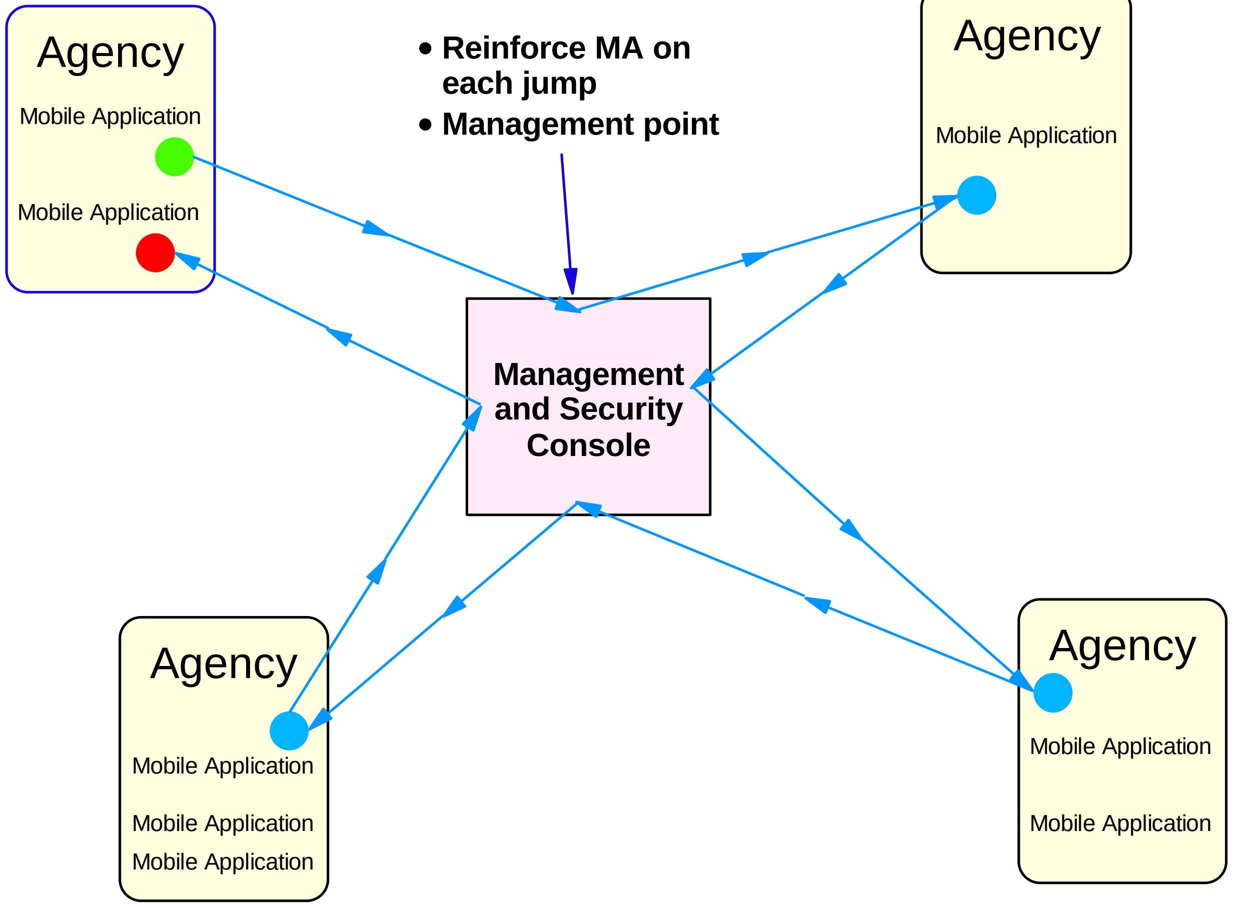
Jumping Beans: Trusted Third Party



- Star architecture enables Jumping Beans' security
- Hosts never communicate directly with each other, hosts communicate with MaSC only
- MAs pass through MaSC on each jump
- Allows secure exchange of MAs with untrusted hosts

Jumping Beans: Trusted Third Party

- 4 independent layers of security
  1. Traditional distributed security
  2. Trusted source
  3. Multi-jump security
  4. Monitoring and intervention
- If one layer fails, the system is still protected by remaining three layers

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Multi-Jump Security

- A host needs to protect itself from MAs
  - Can be implemented with Java's interceptors
- But how much should a host trust an MA?

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Multi-Jump Security *(continued)*

- Each MA is trusted no more than the least trusted host it has visited
  - Each host is assigned a level of trust
    - Fine-grained
    - Looks like an ACL
  - MA's ACL is a most-restrictive composite
    - From ACLs of all previously visited hosts

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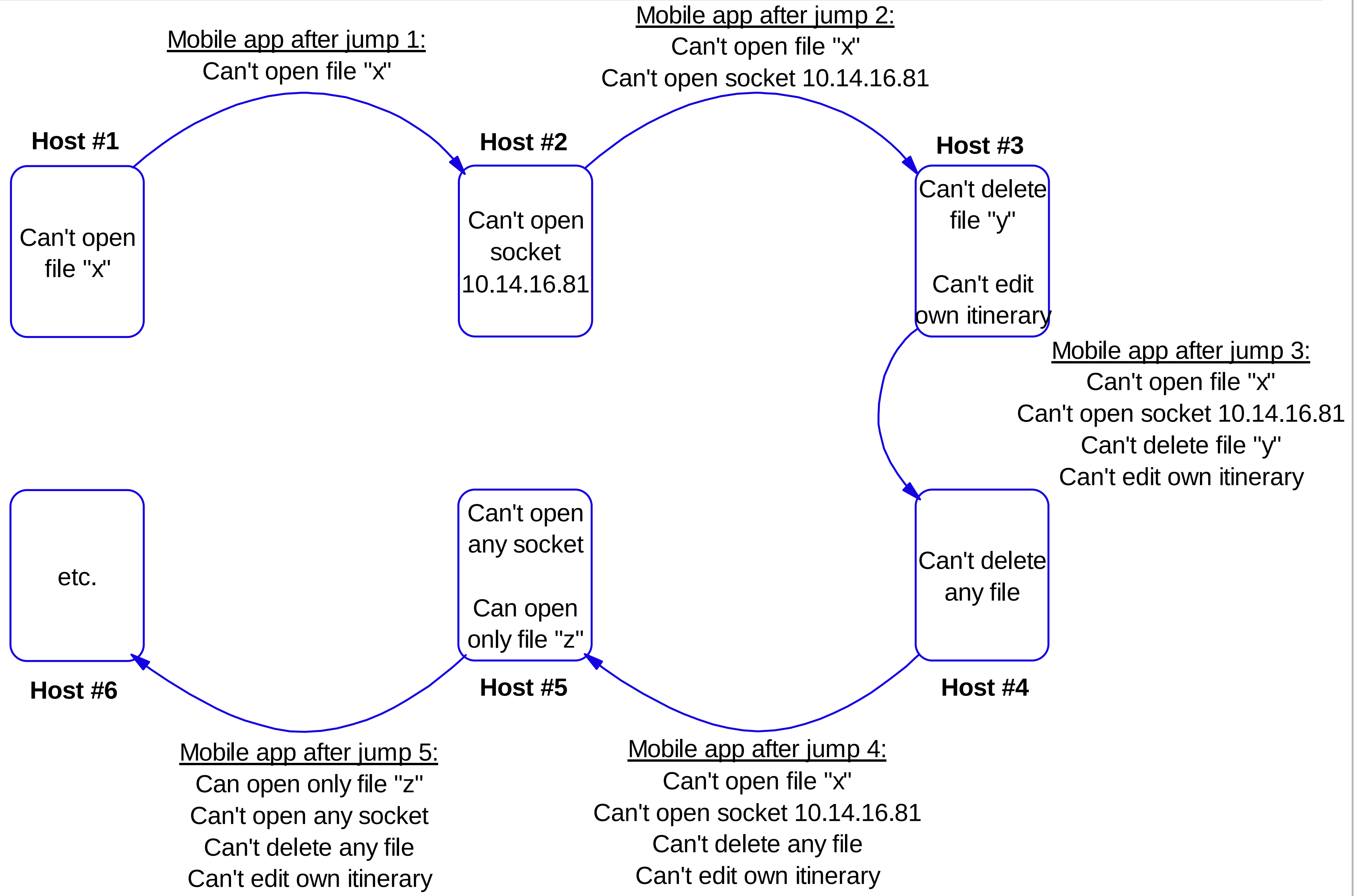
Multi-Jump Security *(continued)*



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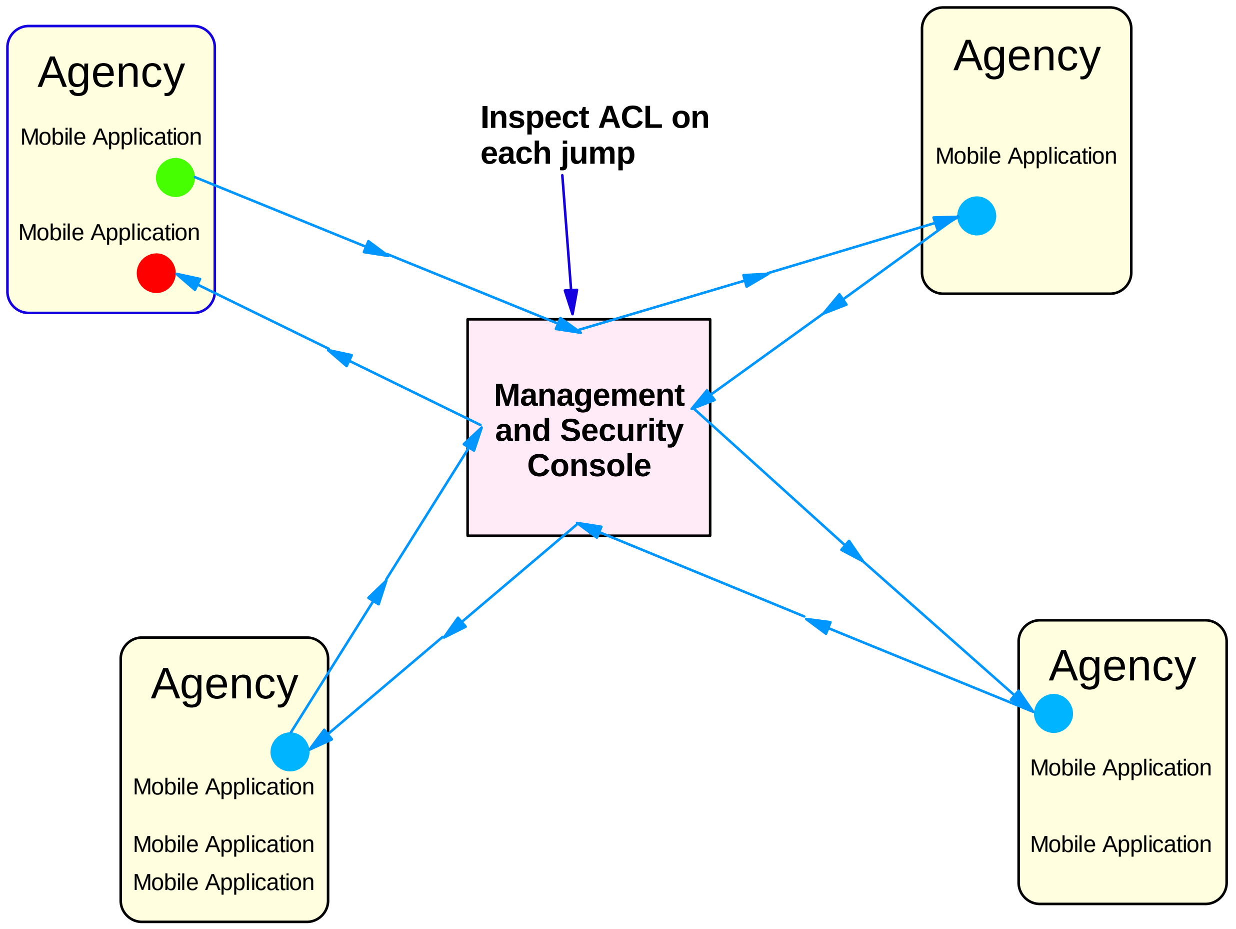
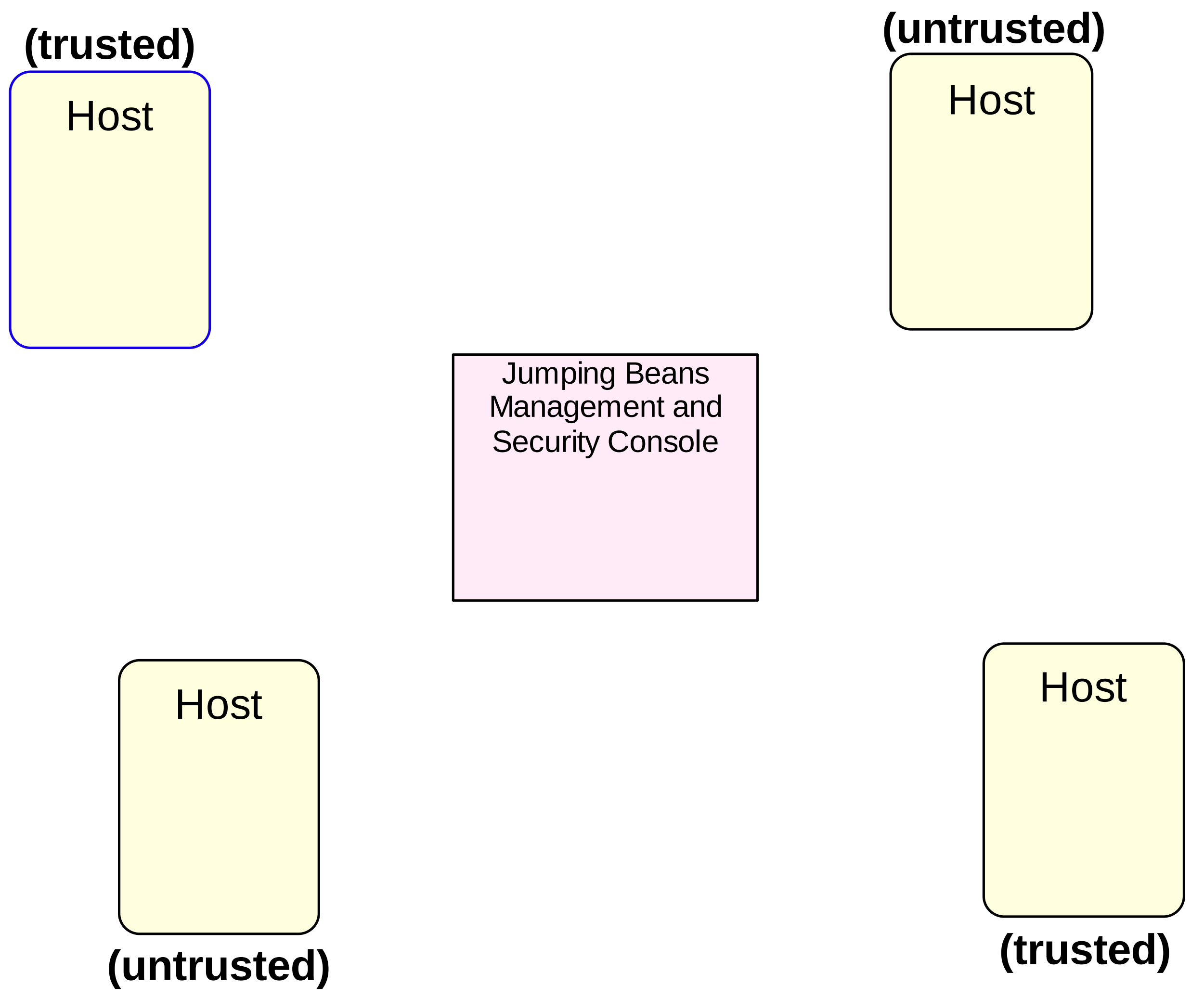
Trusted Third Party: Multi-Jump ACL Assurance



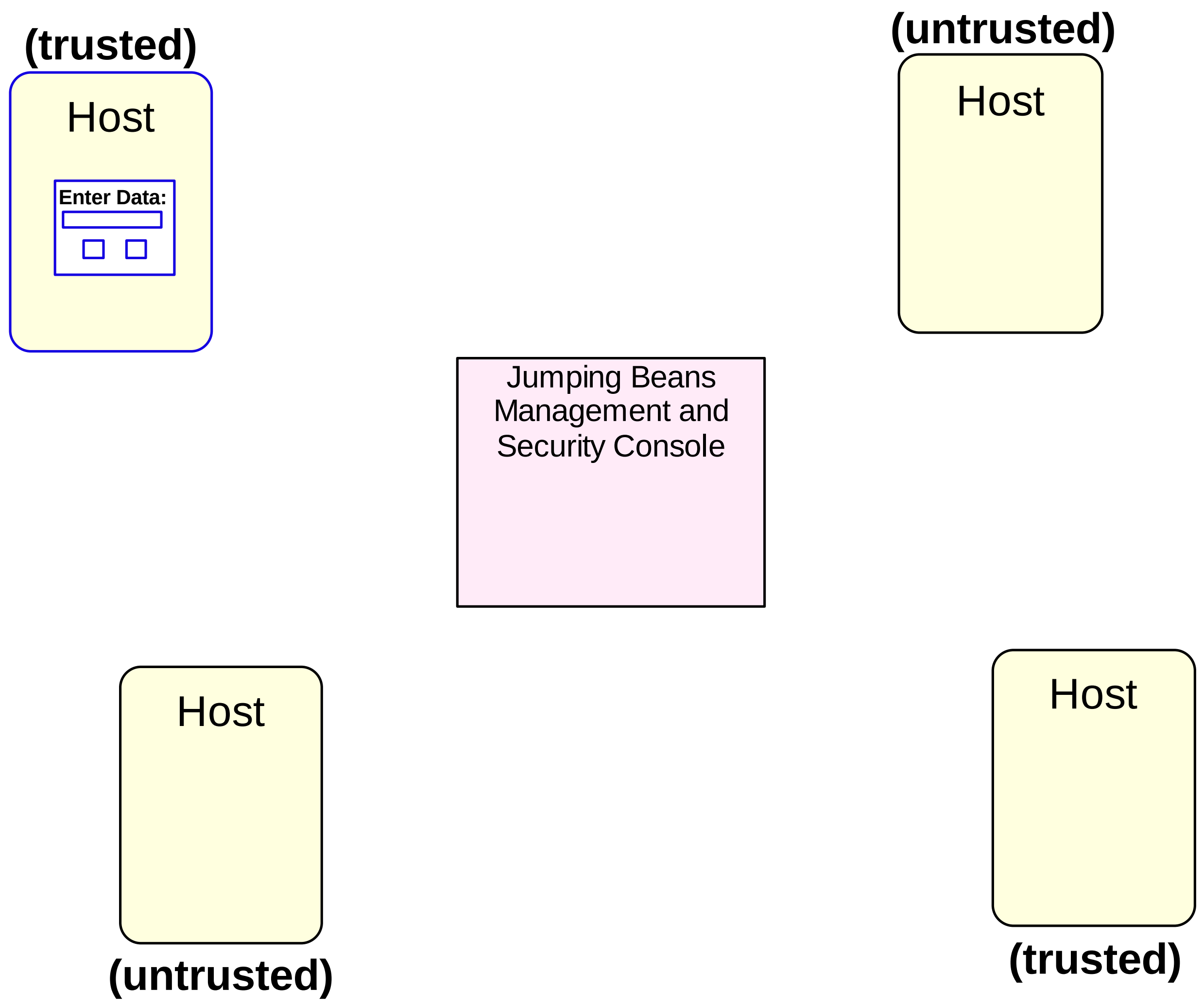
Trusted Source

- Accept code from trusted hosts only
  - System administrator designates which hosts are trusted to transmit code to other hosts
    - At MaSC
- Search protocols locate needed resources from hosts which are designated as trusted
- Partial protection of MA from hostile host

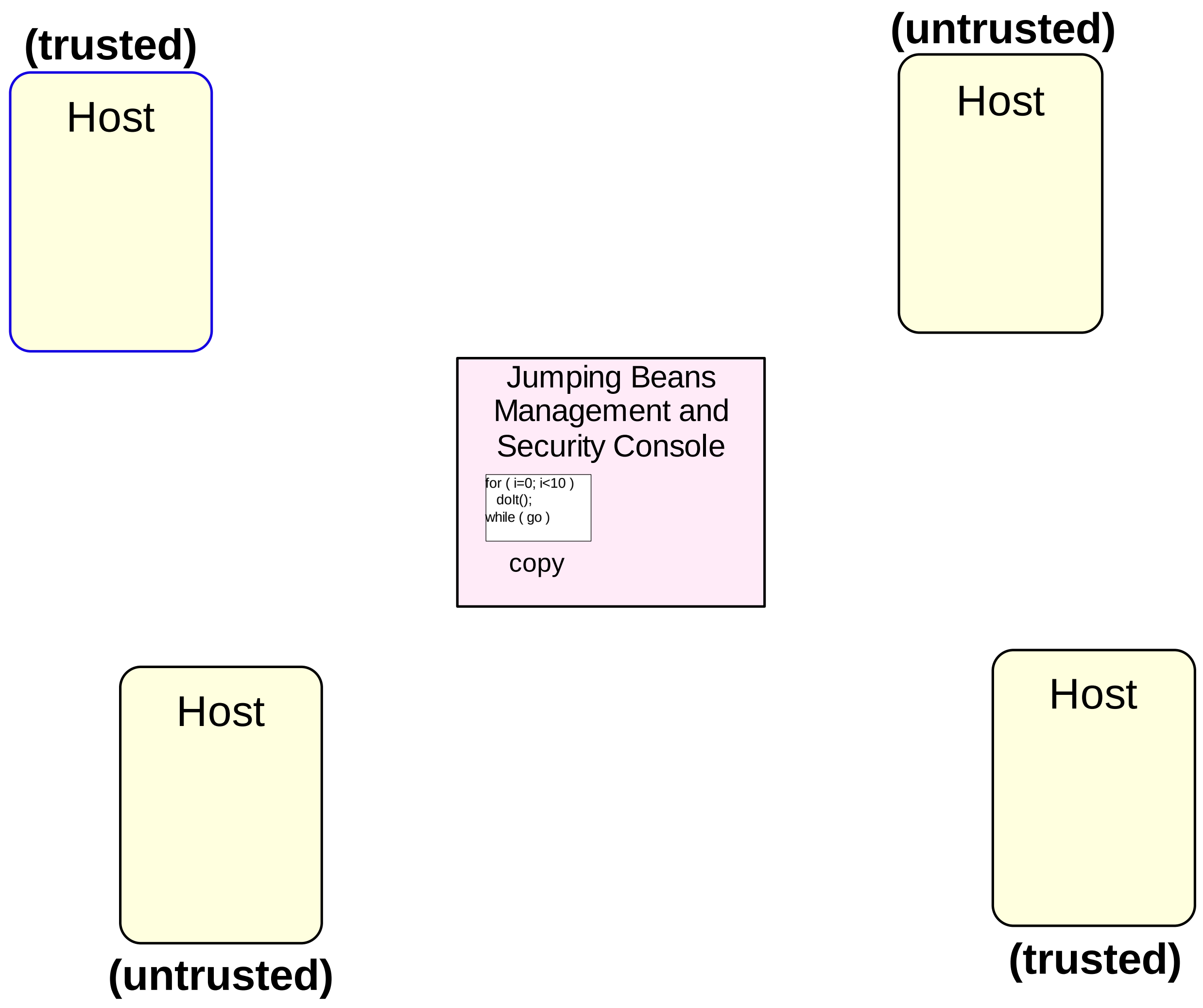
Trusted Source *(continued)*



Trusted Source *(continued)*

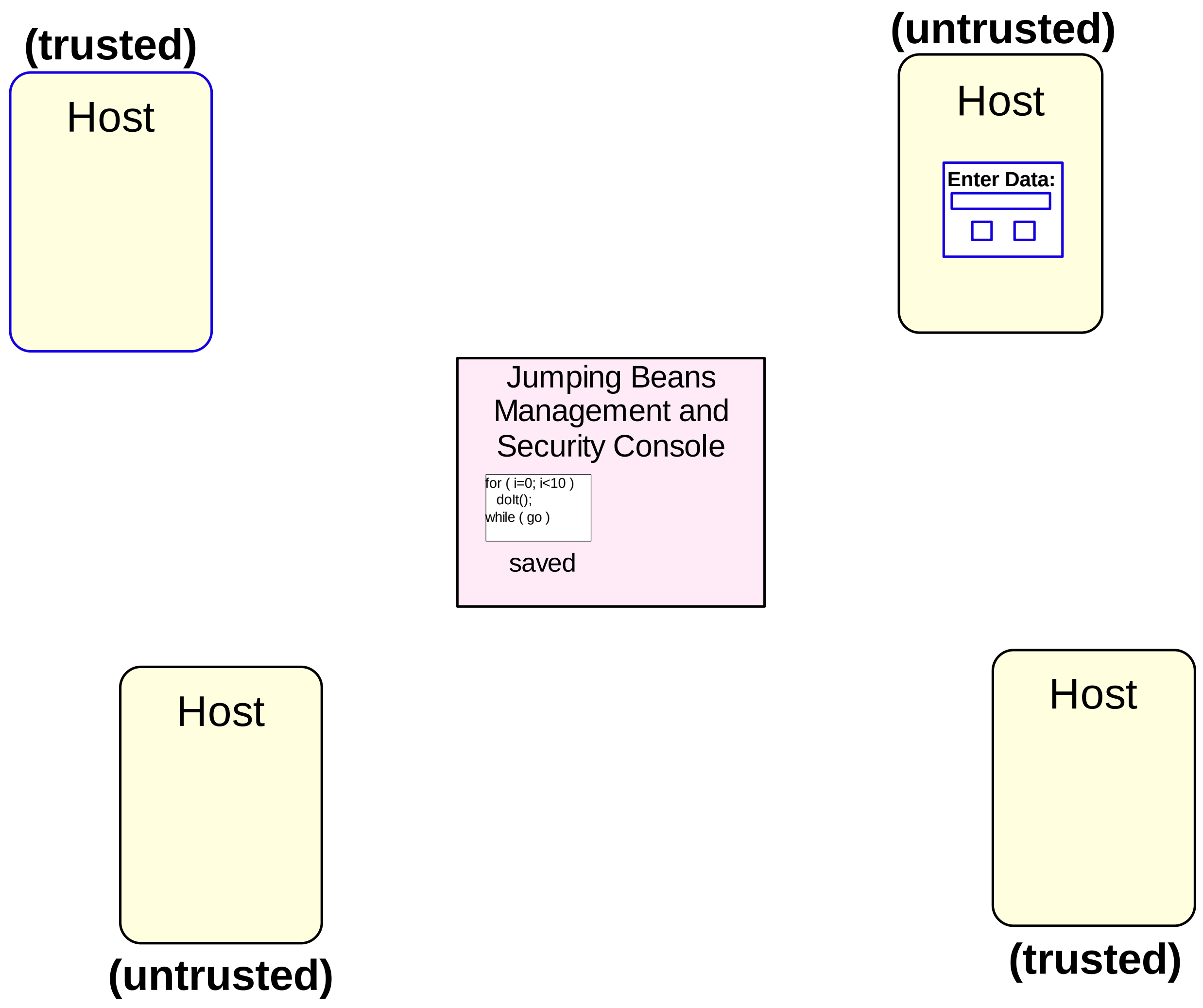


Trusted Source *(continued)*

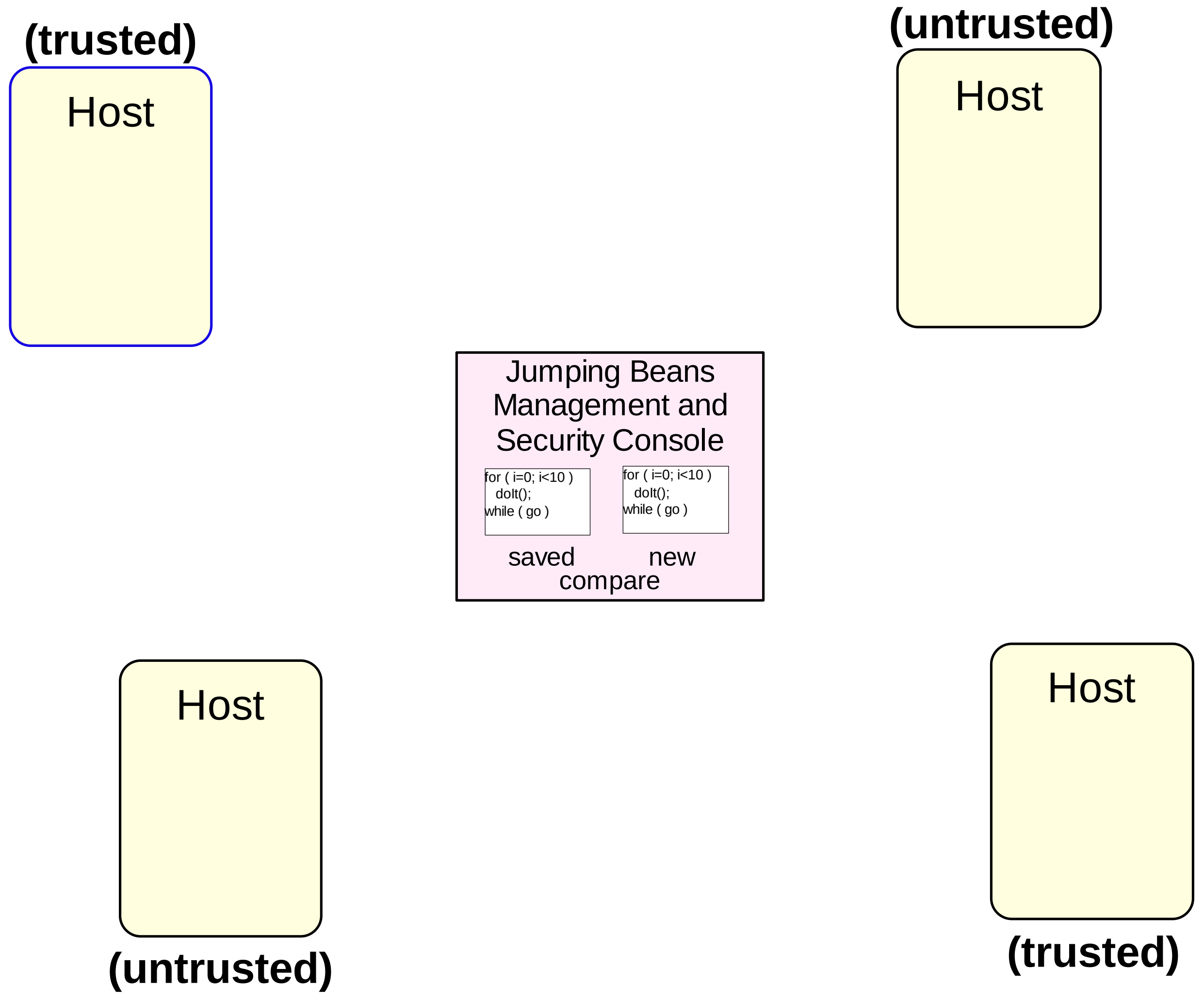


```
for ( i=0; i<10 )
  doIt();
while ( go )
```

Trusted Source *(continued)*



Trusted Source *(continued)*


(trusted)
Host
(untrusted)
Host
Jumping Beans Management and Security Console
for (i=0; i<10) doIt(); while (go)
for (i=0; i<10) doIt(); while (go)
saved
new
compare
Host
(untrusted)
Host
(trusted)

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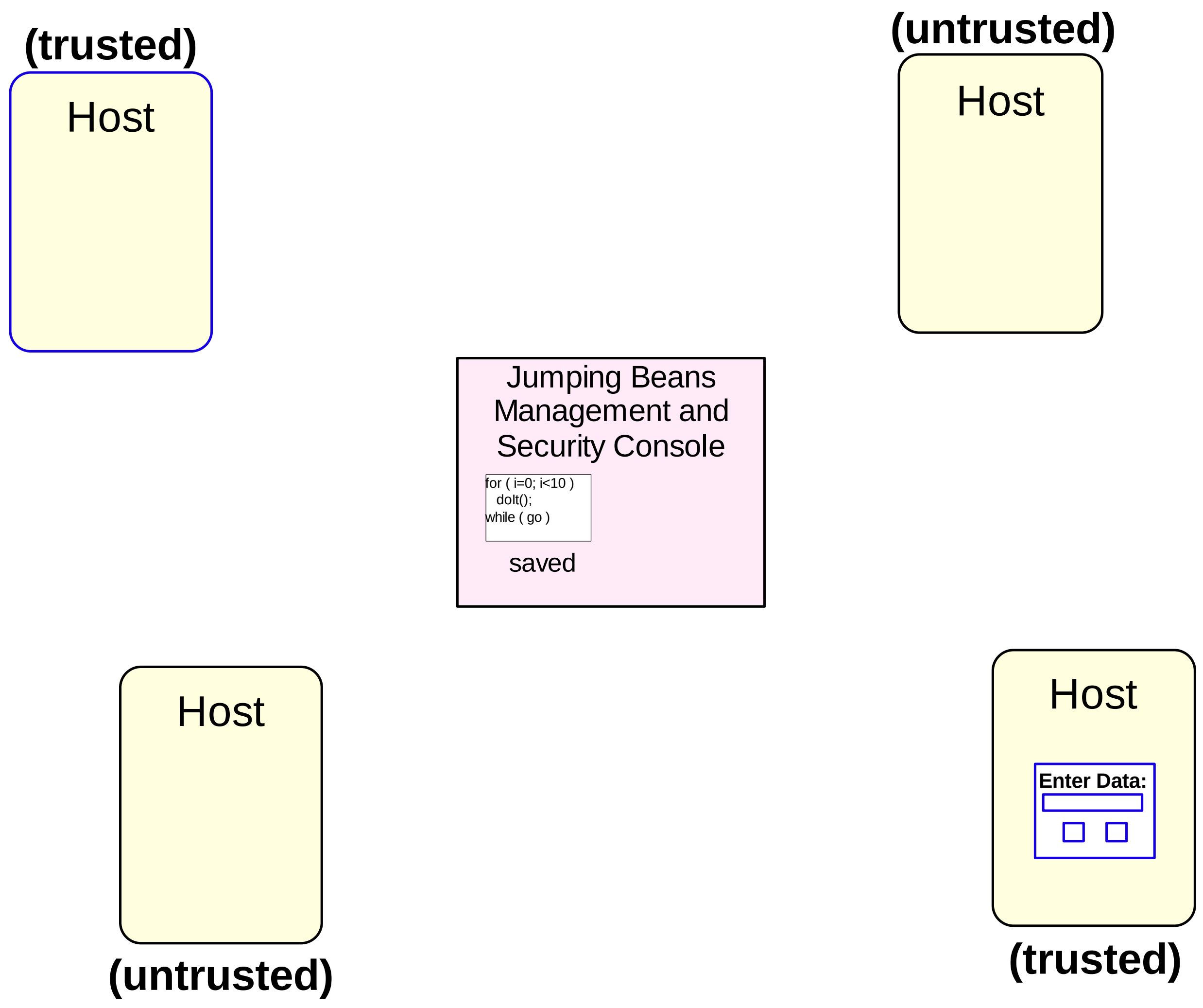
Trusted Source *(continued)*



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while ( go )
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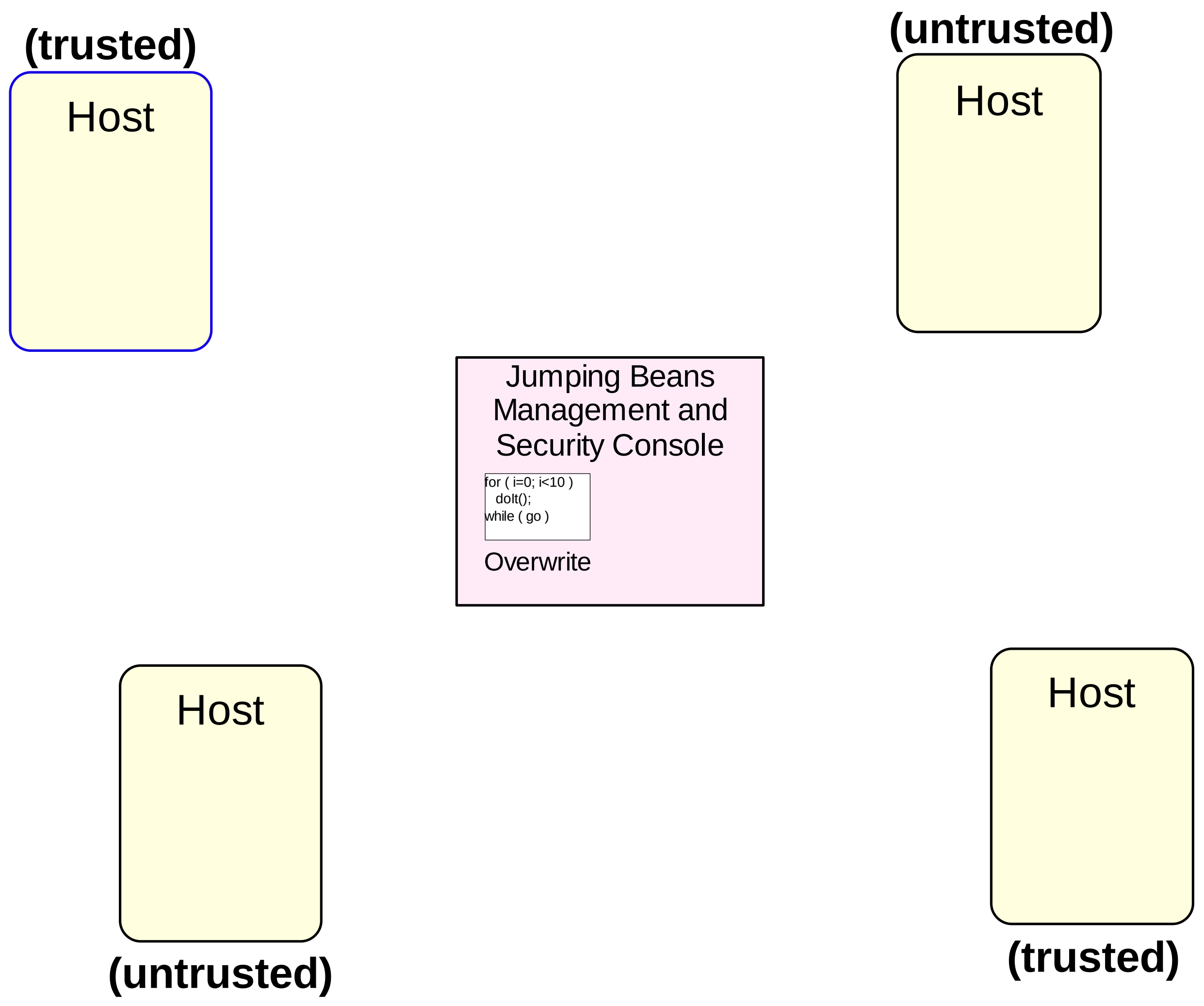
Trusted Source *(continued)*



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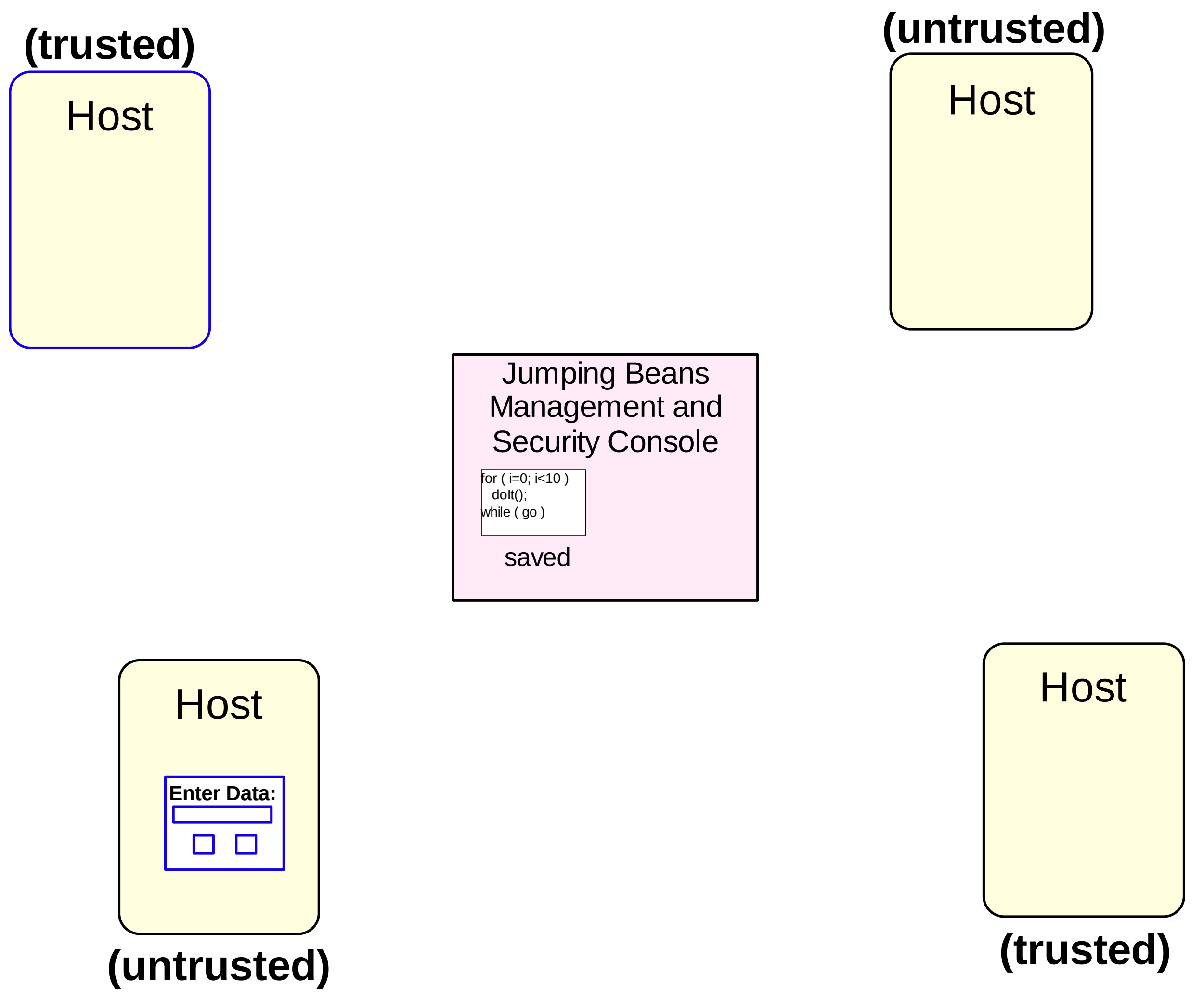
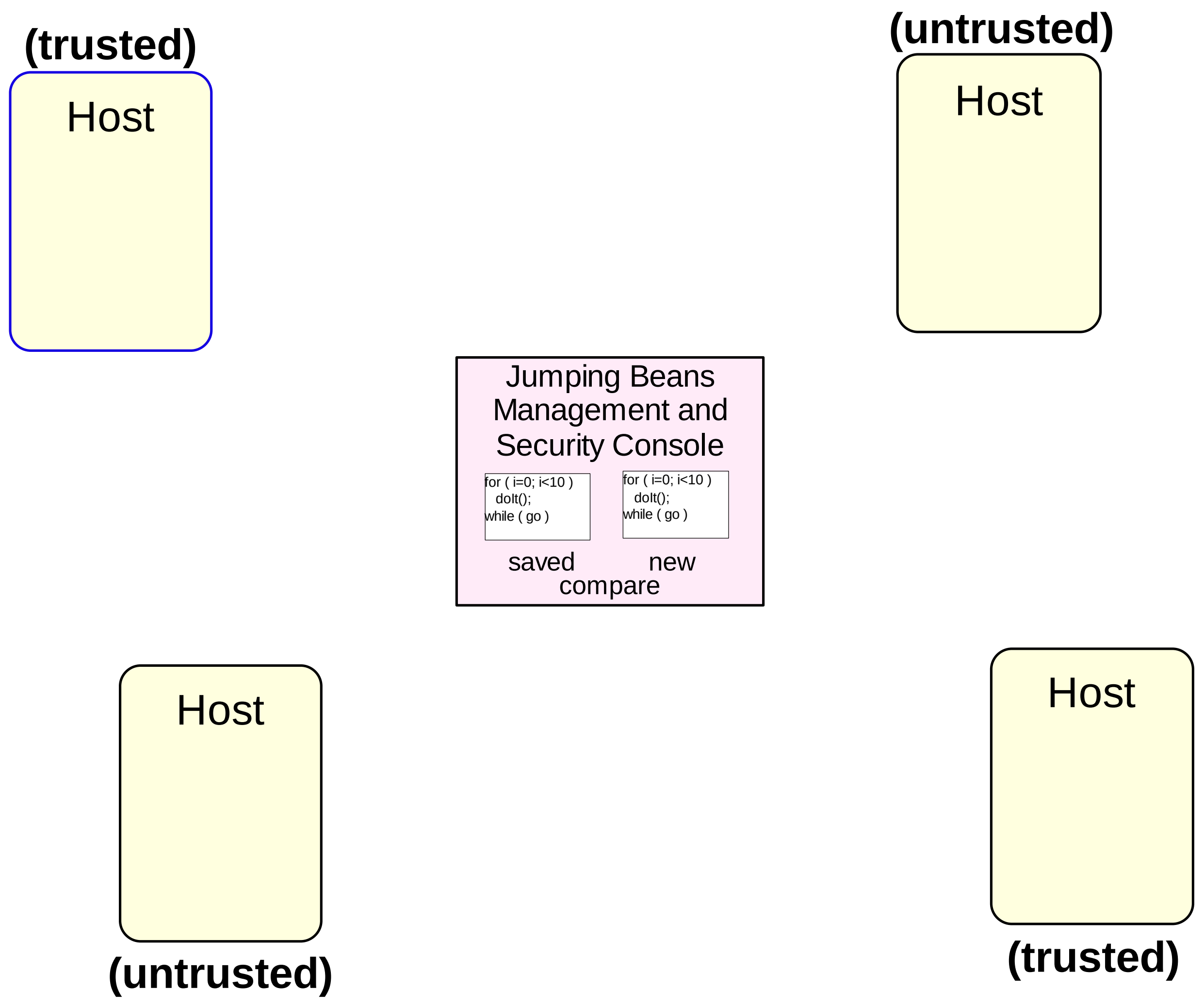
Trusted Source *(continued)*



Trusted Source *(continued)*



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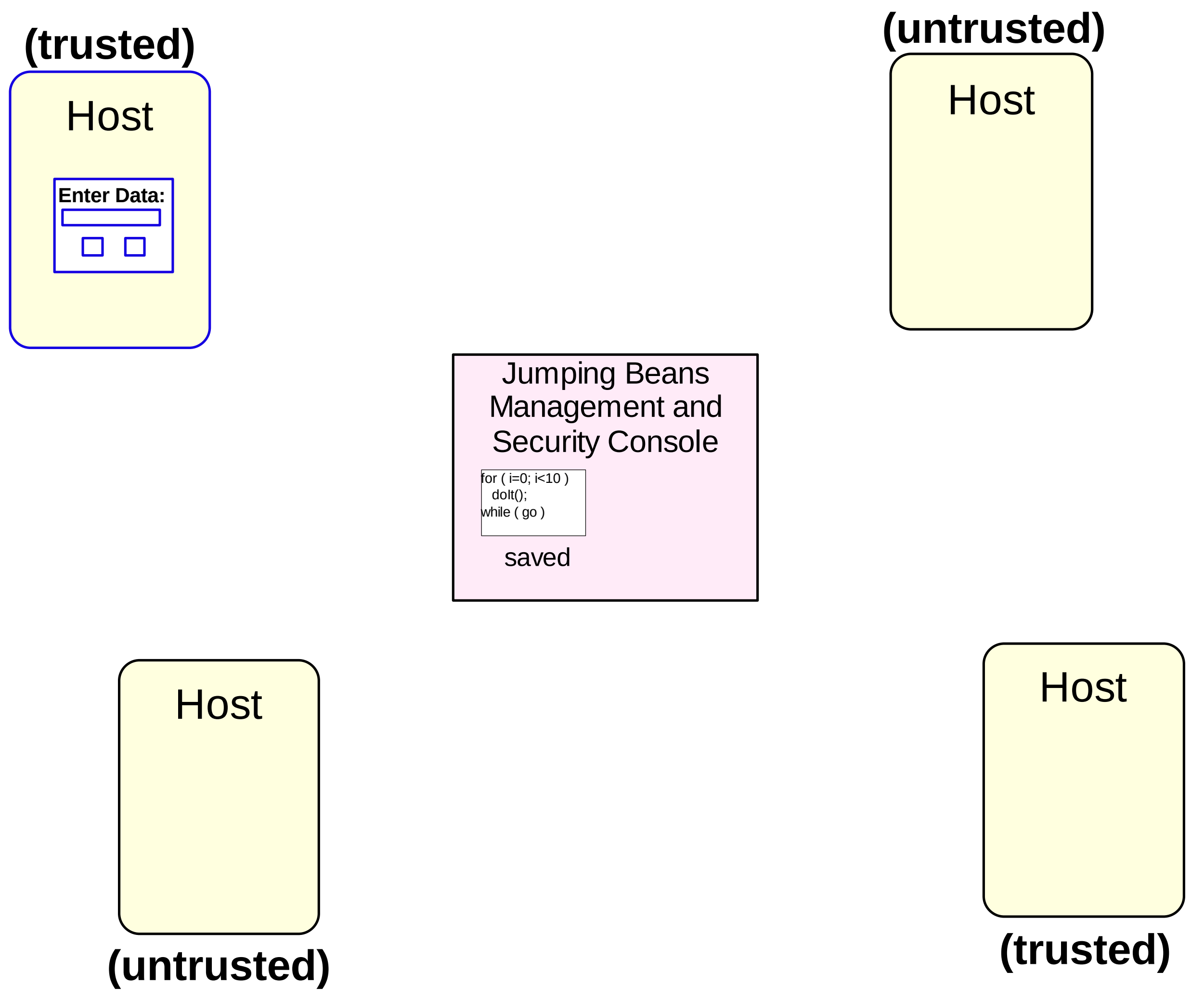
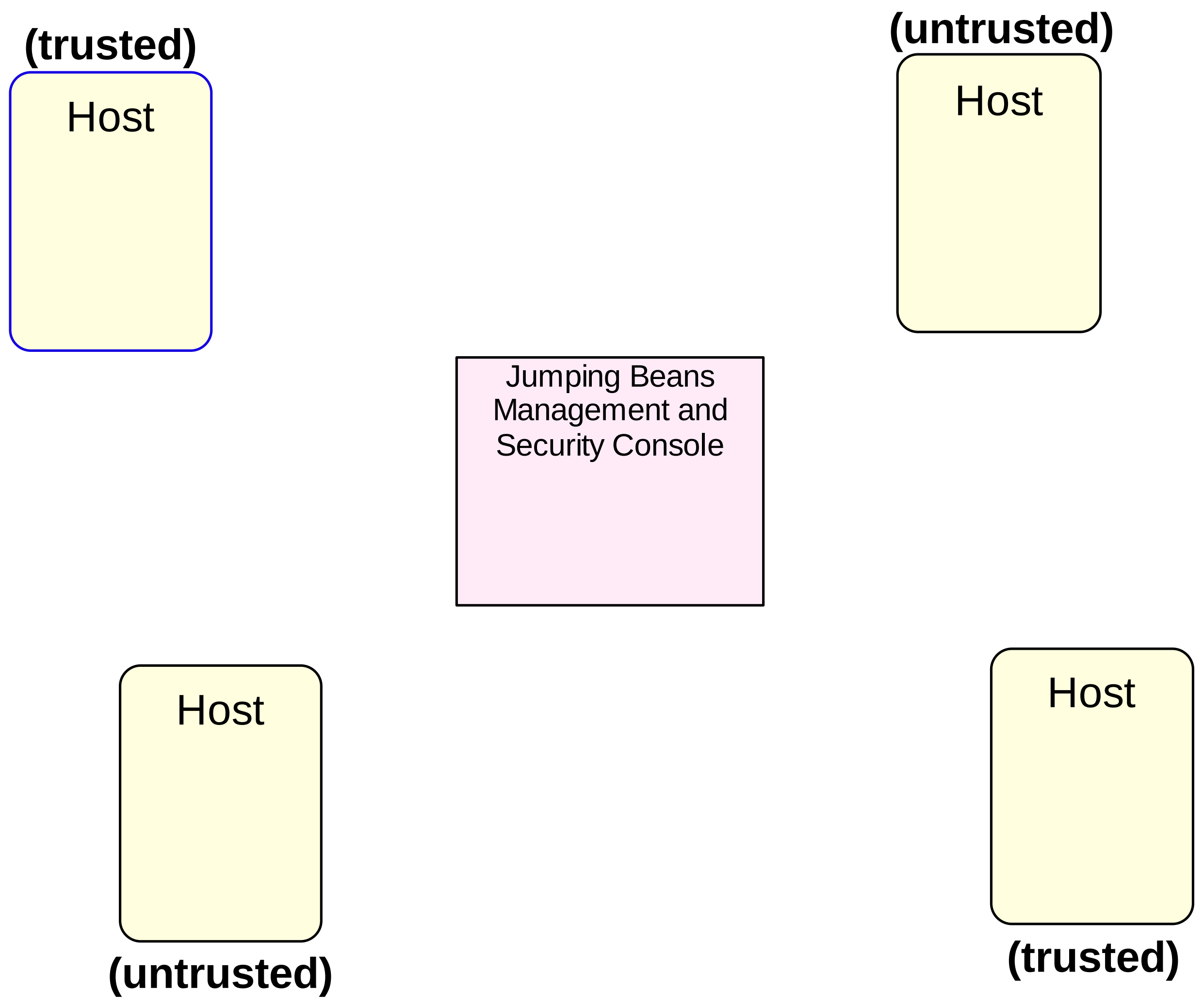
Trusted Source *(continued)*



Trusted Source *(continued)*



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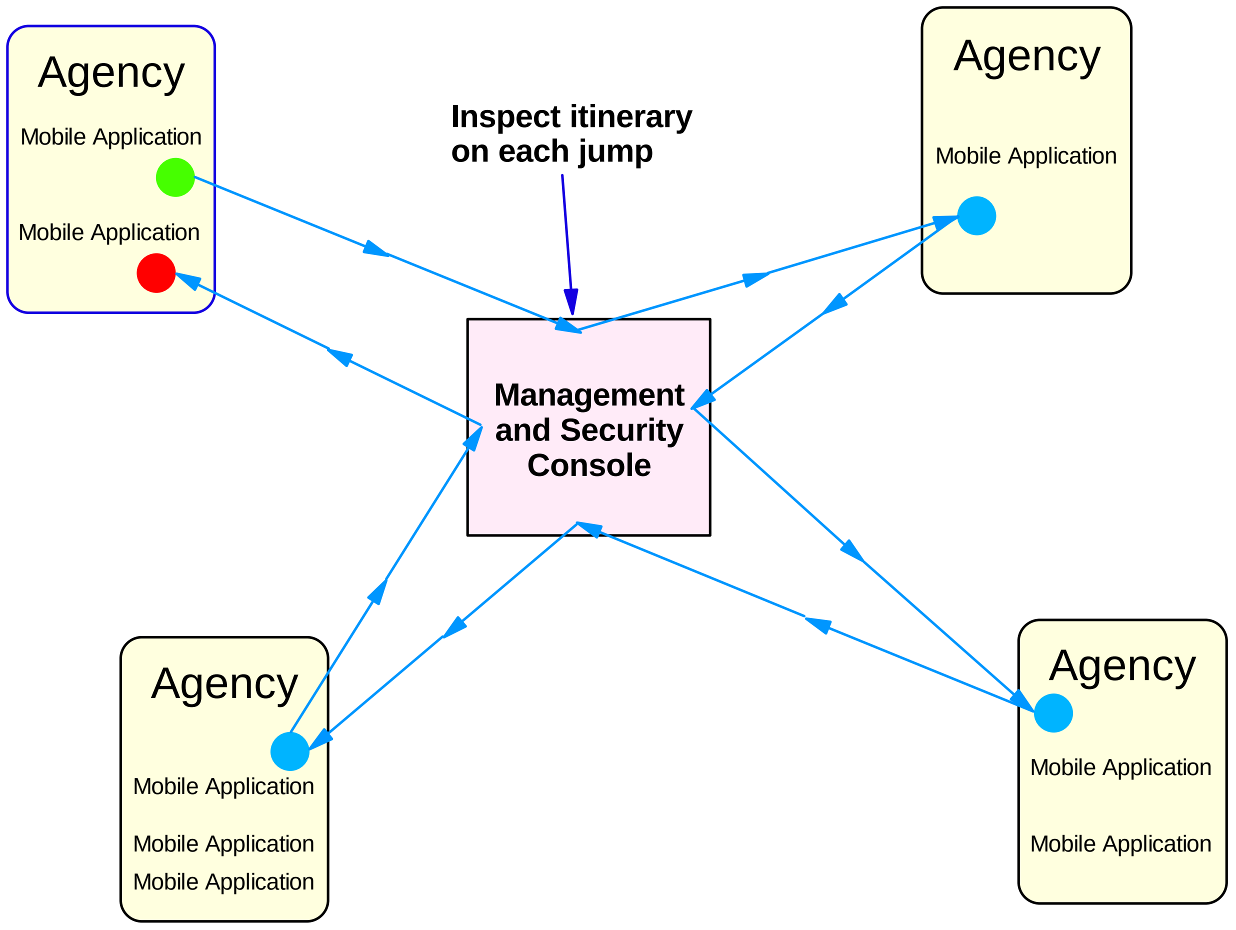
Itinerary Assurance

- Where has it been?
- Where will it go?
- Will it actually go there?

Trusted Third Party: Itinerary Assurance



Trusted Third Party

- Strengths
  - Ideal for IT shop in large corporation
  - The MaSC is the TCB
    - In peer-to-peer, every host must be part of TCB
- Limitations
  - System administrator is trusted by all
    - Not good for mass-market
  - MaSC is single point of security failure
  - MaSC is bottleneck

Encrypted Computing

(Research by Christian Tschudin)

1. Determine required computation
2. Obfuscate data and/or computations
3. Send to other computer
4. Other computer performs operations
    a. Other computer cannot discover what it has computed
5. Send results home
6. De-obfuscate results

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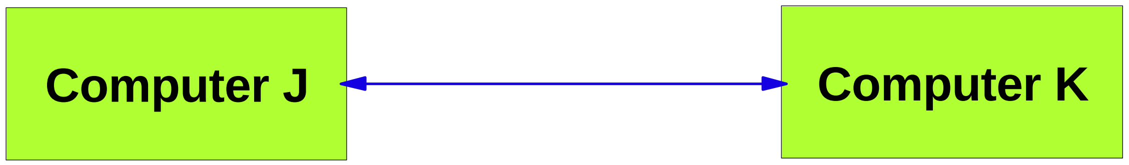
Encrypted Computing: Simple Example



J wants K to compute x*y without discovering x, y, or the product

1. J generates random numbers R_1 and R_2
2. J computes $P_1 = R_1 * x$
3. J computes $P_2 = R_2 * y$
4. J sends P_1 and P_2 to K
5. K computes $F = P_1 * P_2$
6. K returns F to J
7. J computes result $= F / (R_1 * R_2)$

Encrypted Computing: Limitations

- Not yet a general programming language
  - Limited to computing polynomials
- Even if it were expanded to general programming language:
  - Can't hide file access, user interaction, I/O, etc.
  - It is very CPU intensive for both computers

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Signed Code

- Executable file signed by author
  - Prevents tampering
- Limitations
  - Proving authorship does not determine level of trust
  - Certificate management?
  - Does not address other security issues
- Strength
  - Conceptually simple

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Authentication

- Important technique to protect compromised hosts
- Jumping Beans is intelligent about when to issue a challenge
  - Protects stolen device, even before theft is discovered

Conclusions

- MAs can be exchanged with untrusted hosts
  - *Acadamia, DOD have not discovered this!*
- Problems yet to be solved
  - Correct execution of MA by hostile host
    - Partial solutions available
  - Termination of MA by hostile host
    - Probably shouldn't be solved
  - MAs for mass market

Research:
Applications of Mobile Agents

- Intrusion response
  - "White Blood Cells" to eradicate intruders
- Management of heterogeneous systems
  - Send management software on the fly

Mobile Agent Security

Heightened Need for Traditional Security

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Heighted Requirements for Traditional Security

- Mobile applications are extremely powerful
- MAs must be properly handled
  - And they will solve many problems
  - Will cause problems if mishandled

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Signatures Must Keep Hackers Out

- With traditional distributed computing, an attacker can execute known safe code with bad data, perhaps at a bad time
- With MAs, an attacker might insert unsafe code to be executed, with unsafe data, at any time
- Signatures provided by Jumping Beans

Monitoring and Intervention are Critical

- If something is amiss, system administrator must have tools to diagnose and isolate any problems
  - Lost or stolen device
  - Rogue MA
- Jumping Beans' provides this
  - Quarantine or sever any branch of star
  - Real-time display of activity at MaSC
  - Destroy, dispatch, deactivate, etc. any MA
    - From MaSC

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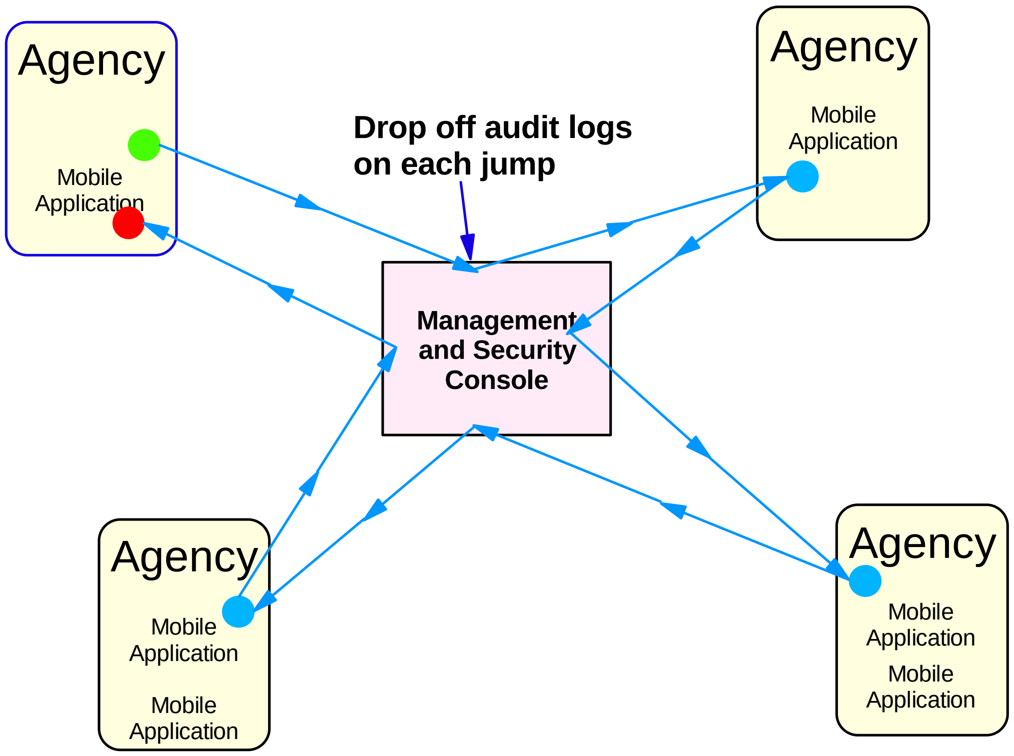
Audit Logs

- Attacker is less likely to strike if he/she can be discovered
- Jumping Beans has indelible audit logs



- Logs can't be attacked by rogue MA
- MAs don't grow too big

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Authentication

- Critical for mobile devices
  - If a mobile device falls into wrong hands, it must not be a door into computing system
- Jumping Beans is intelligent about when to issue an authentication challenge
  - Protects lost or stolen device
    - Even if loss or theft is not yet discovered
  - Currently password based

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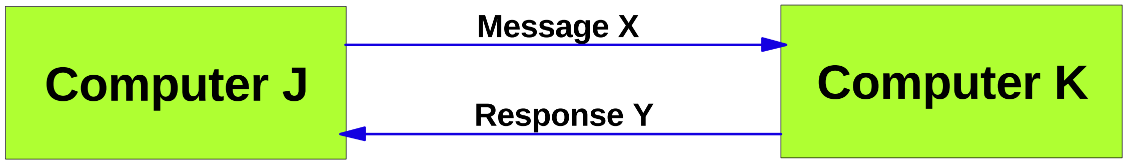
Nonrepudiation

- Because of MAs, interaction between hosts can be very *ad-hoc*
- Evidence must be kept for settling any sort of dispute
- Provided in Jumping Beans



J can prove:

- **Y was sent**
- **Y came from K**
- **Y was intended for J**
- **Y is in response to X, not some other message**

K can prove:

- **X was sent**
- **X came from J**
- **X was intended for K**

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Encryption

- Provides privacy, just like other systems
- Probably no more important for MAs than for other distributed computing systems
- Provided by Jumping Beans

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Replay Prevention

- Difficult to assess importance to MAs, as compared to other computing systems
  - But it is very important, just like other computing systems
- Provided by Jumping Beans

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Manageability

- If the security is difficult to manage, users, developers, and system administrators will turn it off
  - Jumping Beans is easily managed from Management and Security Console
    - Inheriting groups: easily manage many groups

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Jumping Beans' Security Management

- Jumping Beans' security is transparent to system administrator
  - Just configuration
- Jumping Beans security is transparent to app developer
  - Although app developer can interact through API
- Jumping Beans security is transparent to end users