Reverb: Middleware for Distributed Application Forensics

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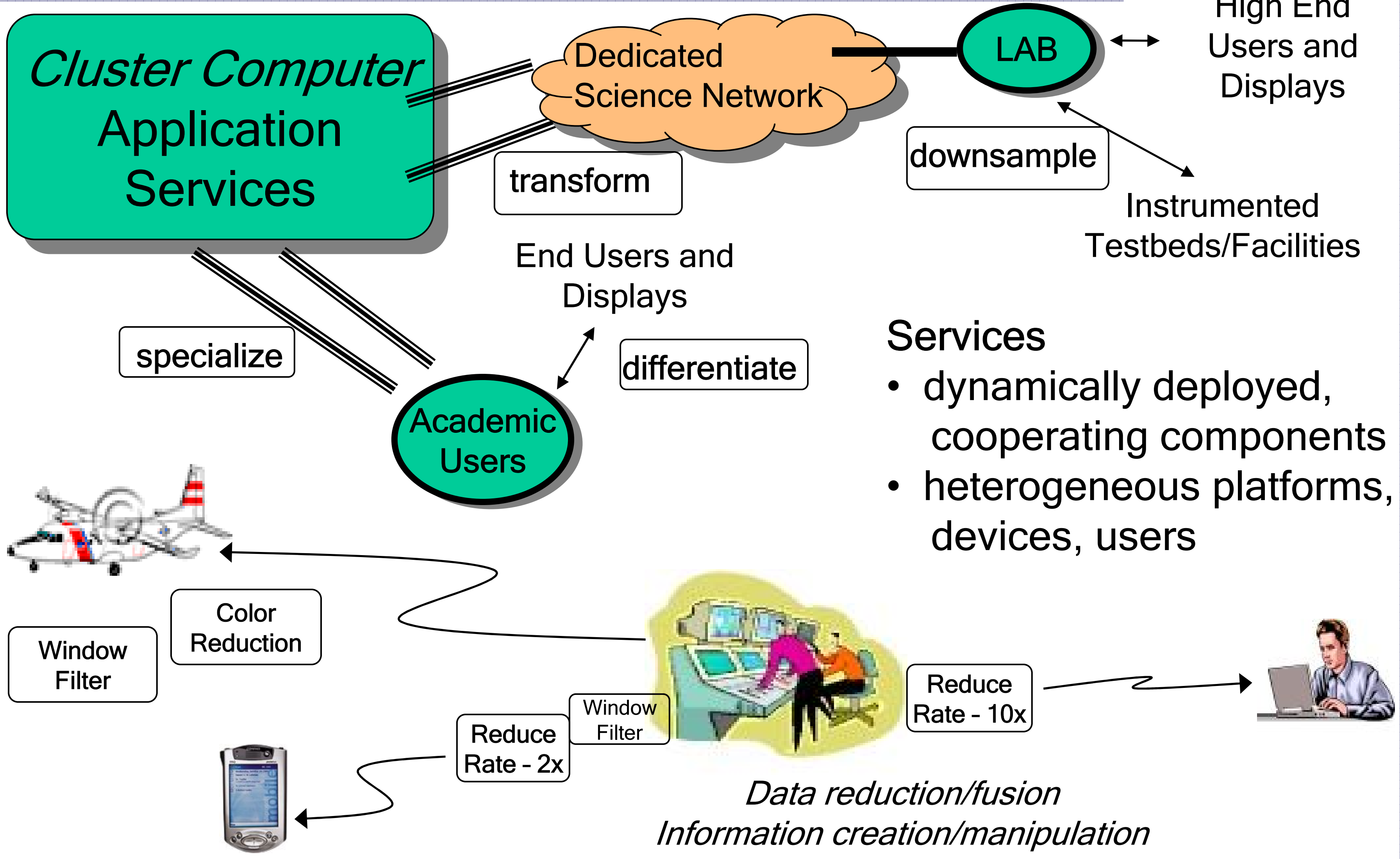
Outline / Contributions

- Context and motivation
- Description of Reverb
  - Differential, customizable, access-controlled auditing for distributed middleware
- Application example
- Experimental results
  - Small performance overhead
  - Preserves application scalability
- Concluding remarks

Example problem domain – scientific application



Services

- dynamically deployed, cooperating components
- heterogeneous platforms, devices, users

Context / motivation

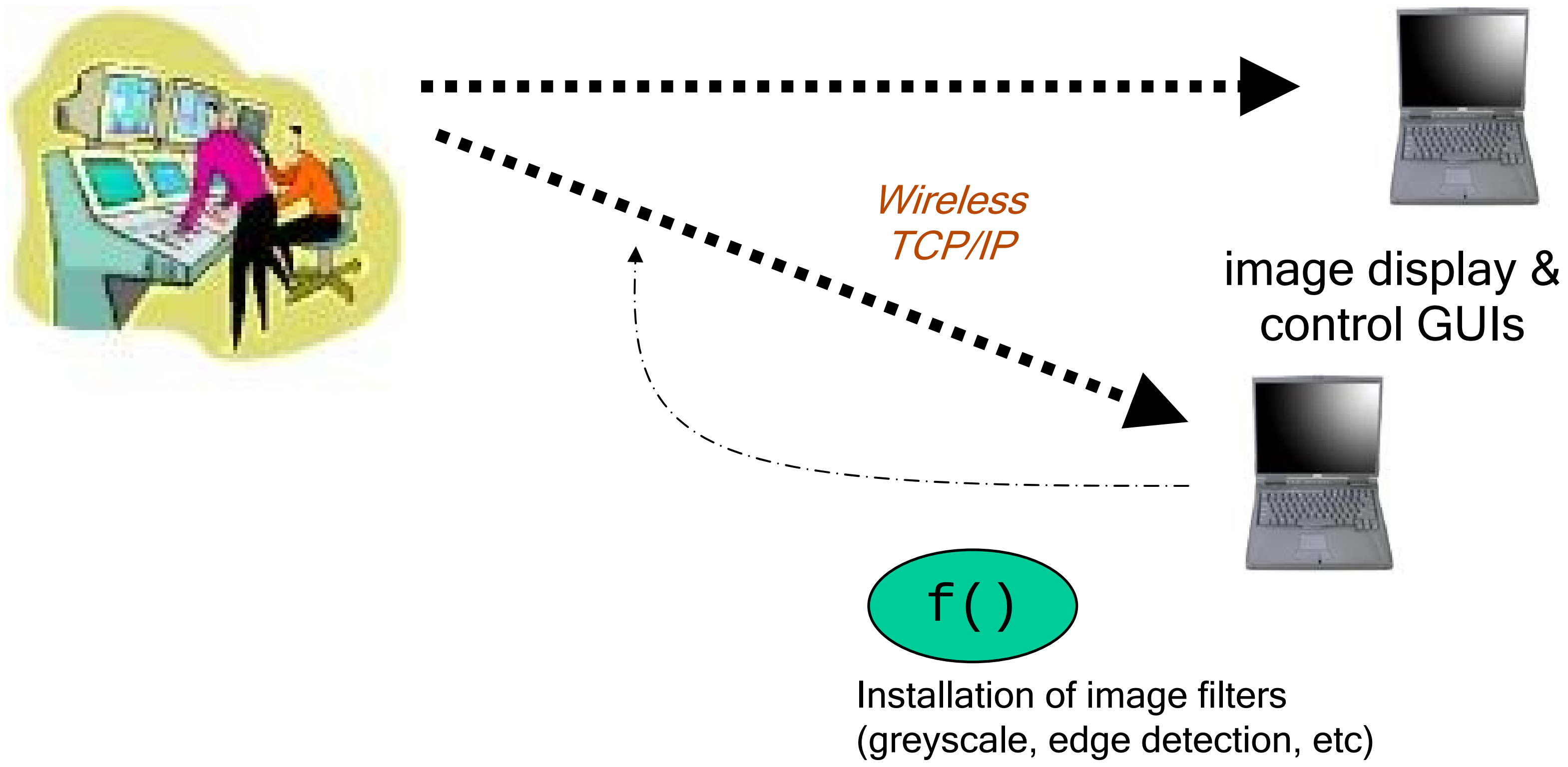
- Application trends
  - Large scale, component-based, dynamically configurable / extensible
- Configuration changes can raise issues
  - System integrity, performance effects, responsibility for outages
- Audit tools for configuration changes help
  - “Paper trail”, on-line or off-line forensic analysis
- Perform audit actions *differentially, dynamically*
  - Differential change control: who can initiate which changes?
  - Differential auditing: which changes are audited, and who sees the audit trail?
  - Change constraints at run-time, without taking applications off-line

Reverb: Dynamic, differential control

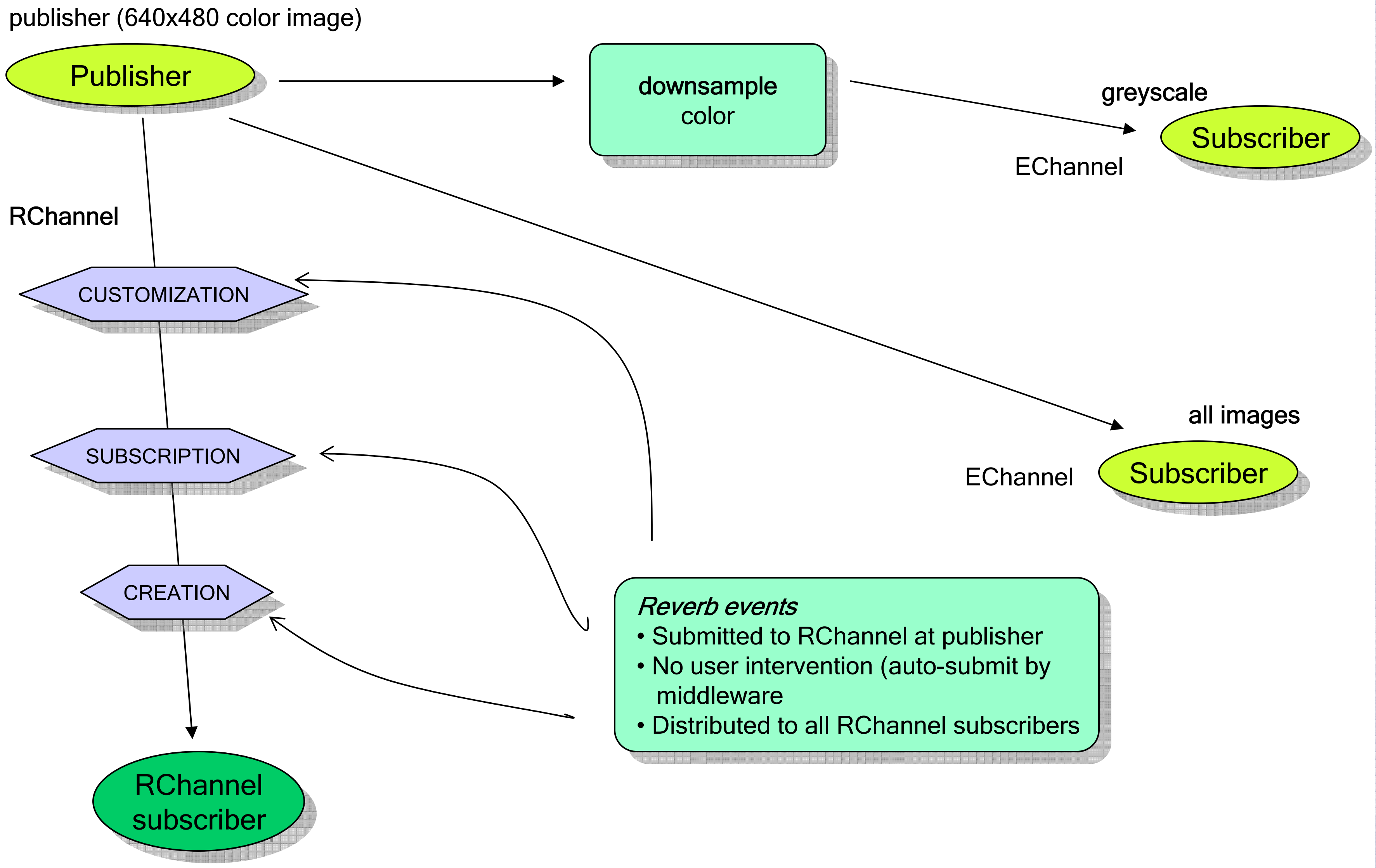
- Reverb provides mechanism to
  - Track dynamic configuration actions
  - Impose controls on permissible actions (which / who)
  - Control access to audit trail
- Dedicated event channel for configuration events (RChannel)
  - Access controlled
  - Differential customization of configuration events
- Implemented in publish/subscribe middleware
  - “ECho” provides customizable event channel abstraction (EChannel)
- Monitored events: channel creation/destruction, subscription, channel customization

Reverb in action

- Sensors, visualization from large science application


Wireless
TCP/IP
image display &
control GUIs
f()
Installation of image filters
(greyscale, edge detection, etc)

Reverb auditing



Reverb events

- Submitted to RChannel at publisher
- No user intervention (auto-submit by middleware
- Distributed to all RChannel subscribers

Differential auditing / change control

- Should any / all users have access to customizations? to the RChannel?
- Policy-driven access to RChannel, customizations
  - Per-principal, per-customization basis - *differential*
- Reverb provides protected access
  - ECho protected mode – *capabilities* required
  - Dennis & Van Horn style – reference + rights
  - Cryptographic protection against forgery / replay
  - Trusted policy module (Overwatch) to issue / sign capabilities
- Configuration policy statements (XML) at startup, during execution
  - Policy statements can dictate differential actions
  - Overwatch creates differential code, RChannel references

Specifying customizations

- Coarse-grain: by configuration type
  - CREATION, SUBSCRIPTION, CUSTOMIZATION, etc.
- Fine-grain: based on application spec
- How to specify? How to execute?
  - Dynamically compiled filter functions
    - Safe(r) subset of C
    - Execution at source
    - Satisfies large % of needs
  - DLL / shared objects
    - More complex filtering
    - Stateful

Evaluated in the context of a function declaration of the form:

int F({ <*i-stream*> input }, { <*o-stream*> output })

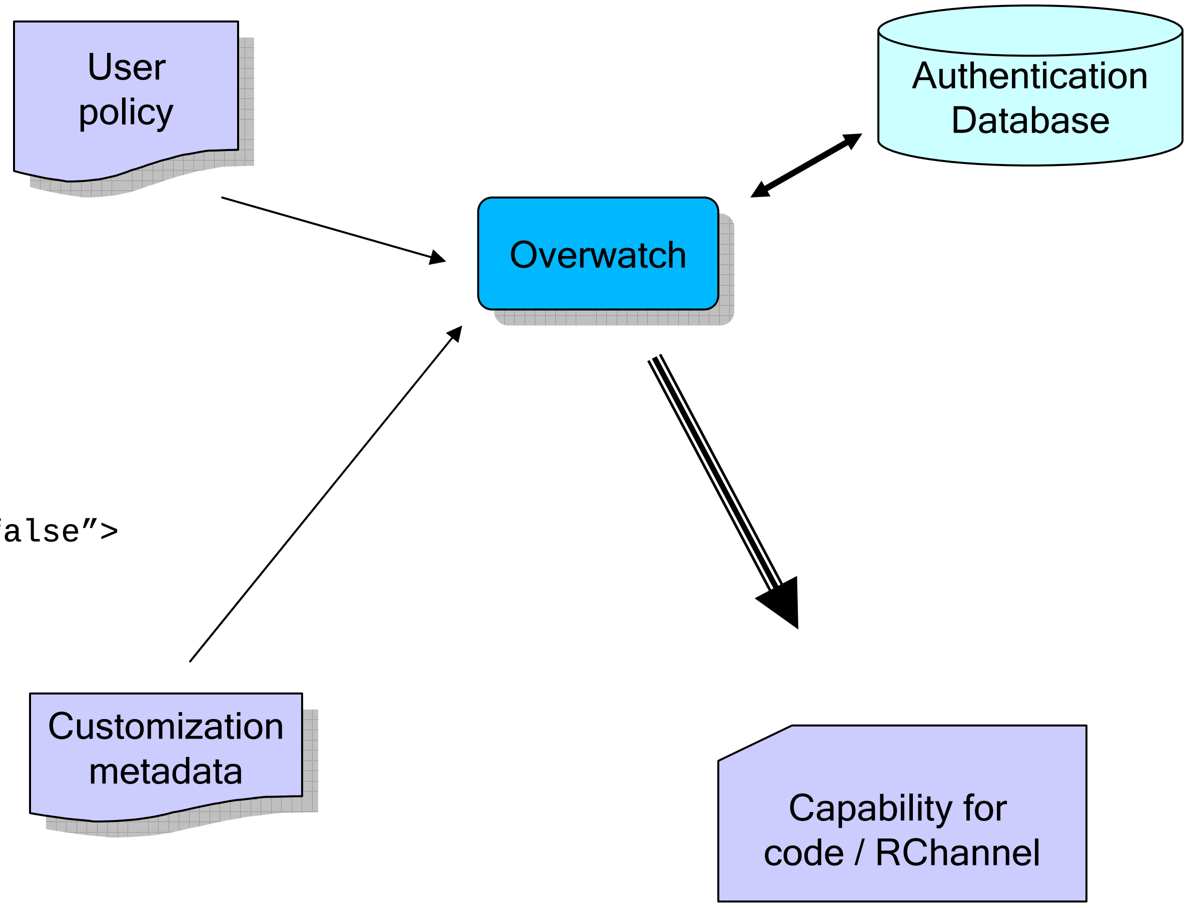
```
{
     int i, j;

    if (input.principal == “BOB”) {
      if (input.config_type == CREATION) {
        return 1; /* interested */
      else
        return 0; /* filter out */
}
```

- Configuration event structures published in API

Reverb policy statements

```
<userPolicy>
<name> Bob </name>
<Reverb-restrictions>
<auditDisallowed>
  CREATION
</auditDisallowed>
</Reverb-restrictions>
</userPolicy>
```

```
<customization takesParams="false">
<name> greyImage </name>
<code>...</code>
<Reverb-actions>
  <disallowUser>
     Bob
  </disallowUser>
</Reverb-actions>
</customization>
```



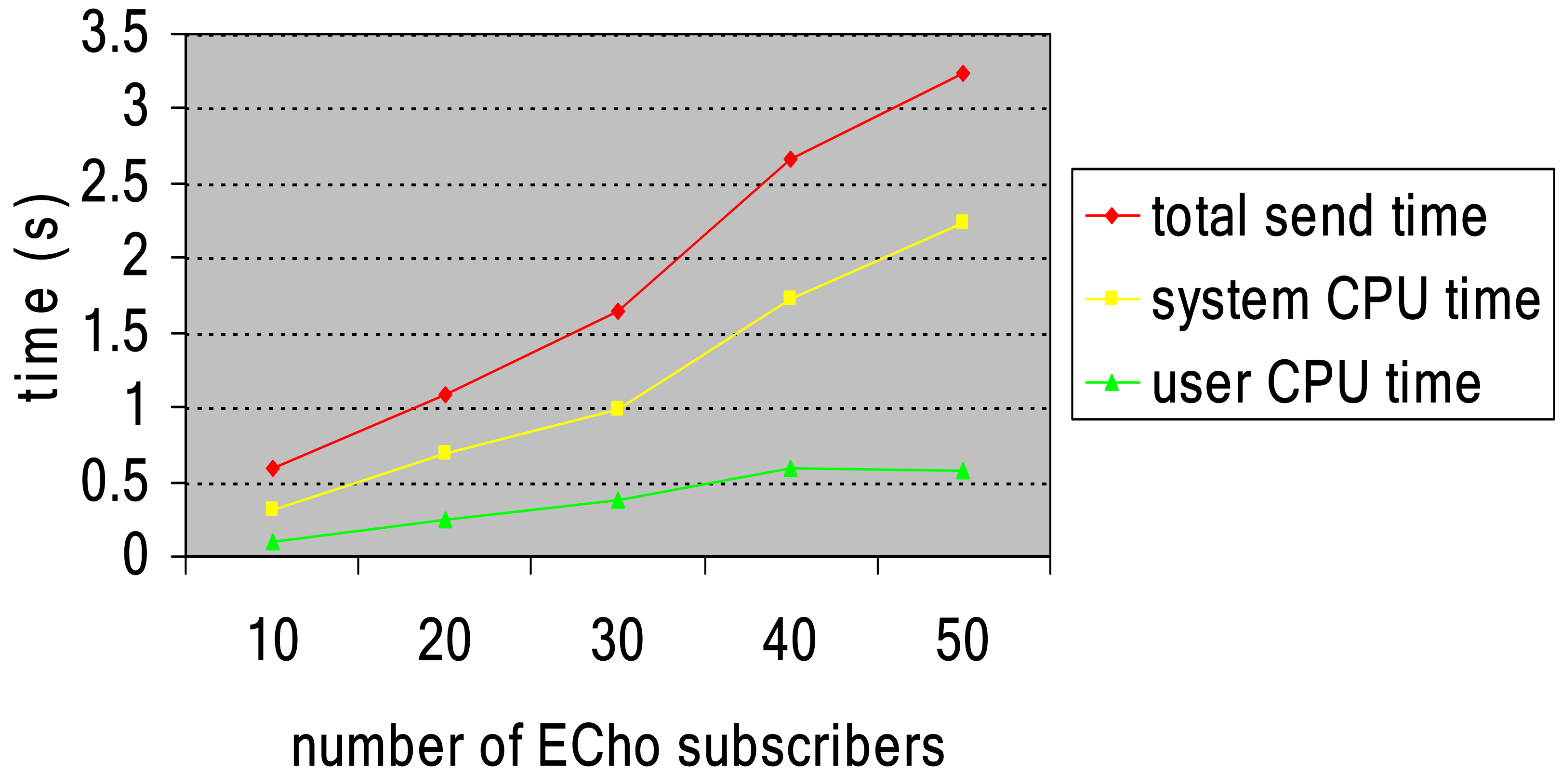
Customized, protected RChannels

- More efficient event propagation
- Applications define exactly what information goes to what principals (least privilege)
- Subdivide audit processing
  - Monolithic audit de-multiplexer unwieldy, complex
  - Instead, small audit components, each with specialized task
- Dynamic policy reactions at Overwatch
  - Disable customizations for suspect users
  - Disable suspect customization code

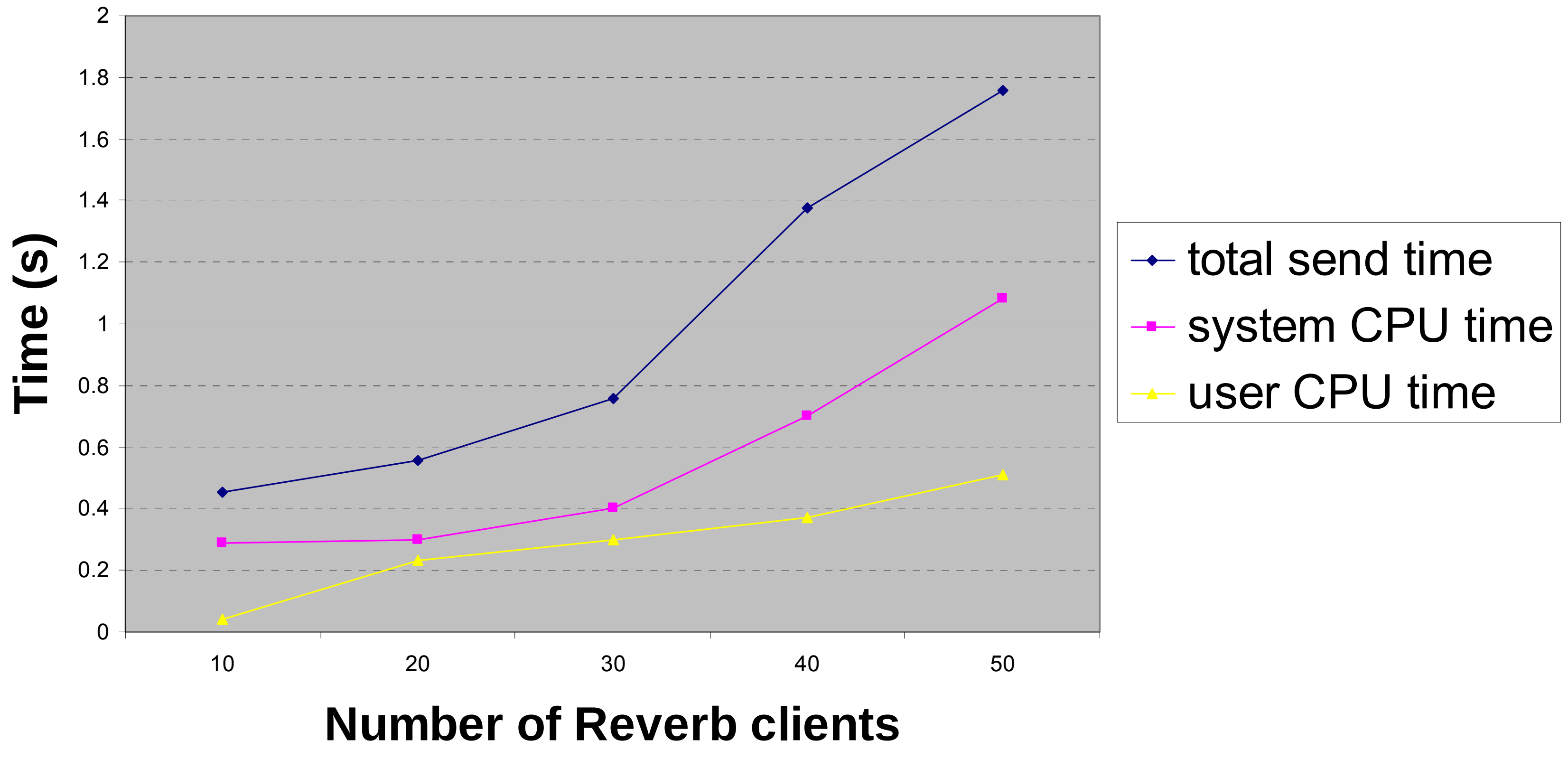
Reverb protection overhead

- Protection mechanisms profiled against unmodified middleware
- Overheads
  - Channel create, subscribe, filter uninstall are small (3-5%)
  - Customization larger (~8%), but more XML, communication, crypto
- *Most overheads outside data path* – cost is amortized

Reverb Scalabilty
(5 Reverb clients, action script)



Reverb Scalability - Multiple Client Customizations (20/80)



Conclusion

- This talk has described Reverb
  - Middleware mechanism to support auditing and forensics for large distributed applications
- Customizable, protected, efficient dissemination of configuration information
  - Customizable – Subscribers choose which configuration events they wish to see
  - Protected – only principals authorized by application policy can access RChannel
  - Efficient – tolerable overheads, scalability as Reverb and non-Reverb subscribers increase
- Dynamic, differential auditing, change control
- Part of larger work on data protection in high-performance, pervasive applications

Questions?