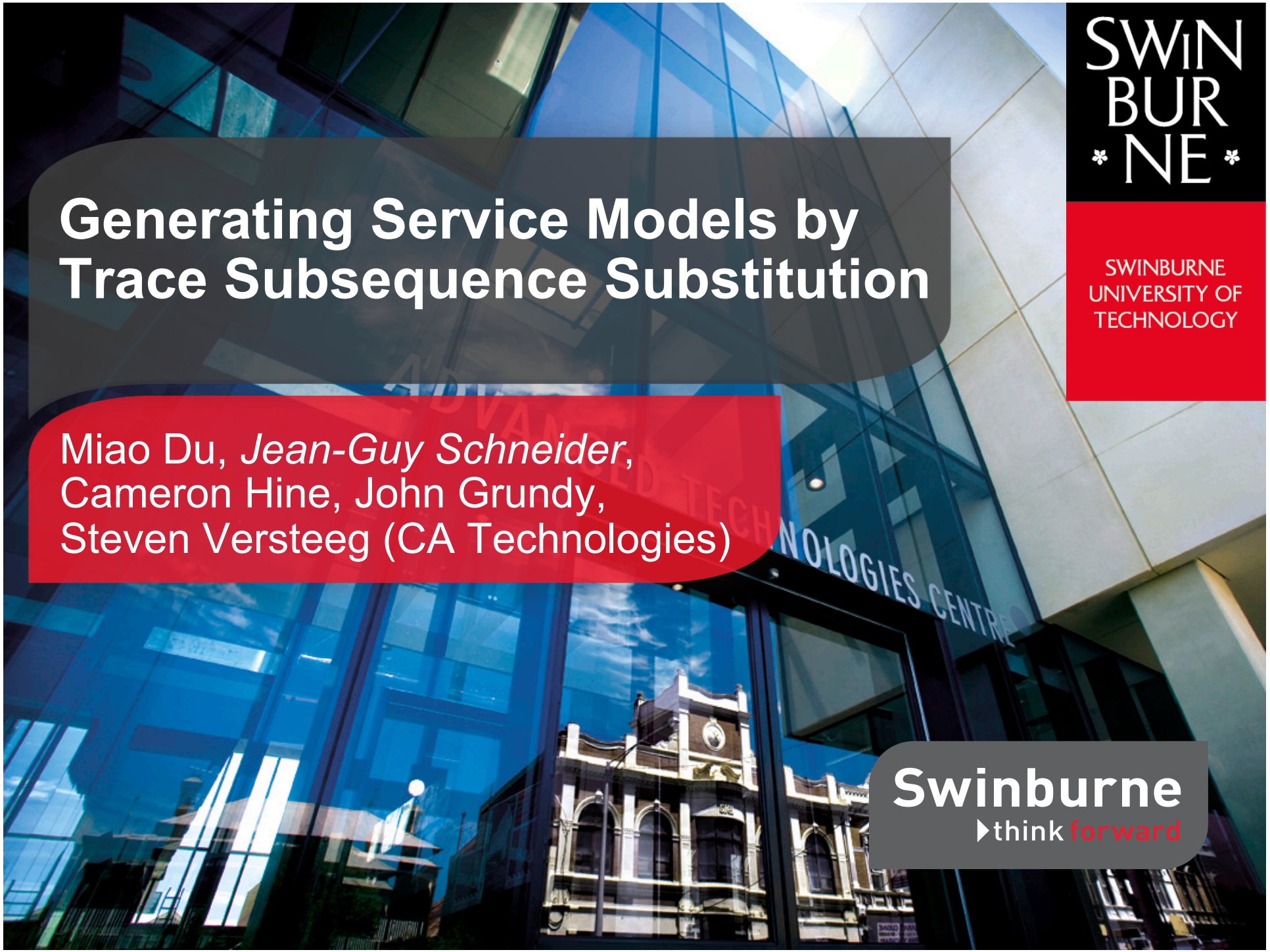

Generating Service Models by Trace Subsequence Substitution

Miao Du, *Jean-Guy Schneider*,
Cameron Hine, John Grundy,
Steven Versteeg (CA Technologies)

SWINBURNE UNIVERSITY OF TECHNOLOGY

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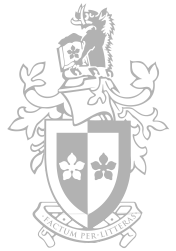
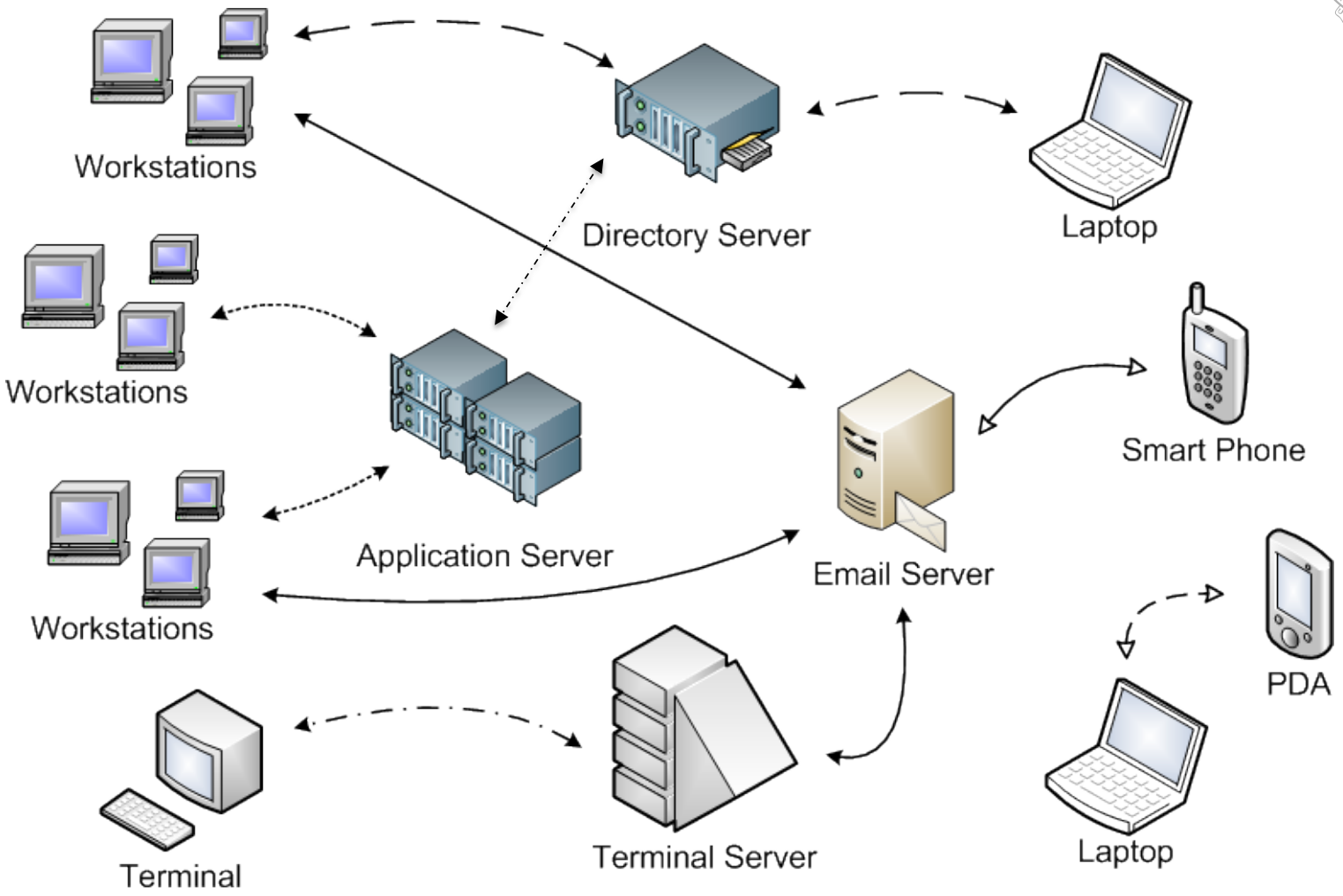
Overview

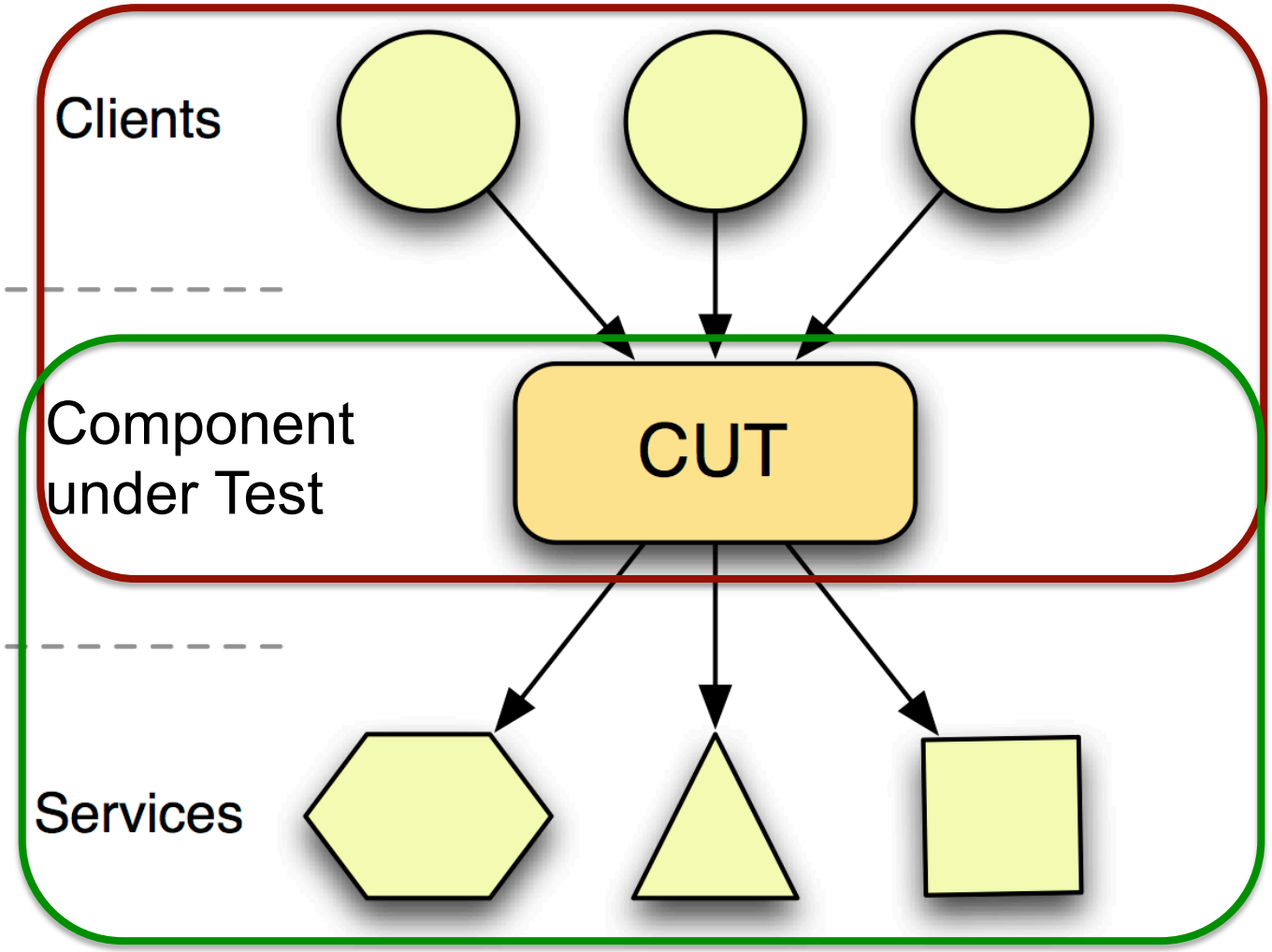


- Context
- Environment Emulation
  - Basic Idea
  - Problems of Existing Emulation Approach
- Novel Framework for Executable Endpoints
  - Similarities and Symmetric Fields
- Evaluation
- Conclusions and Future Work

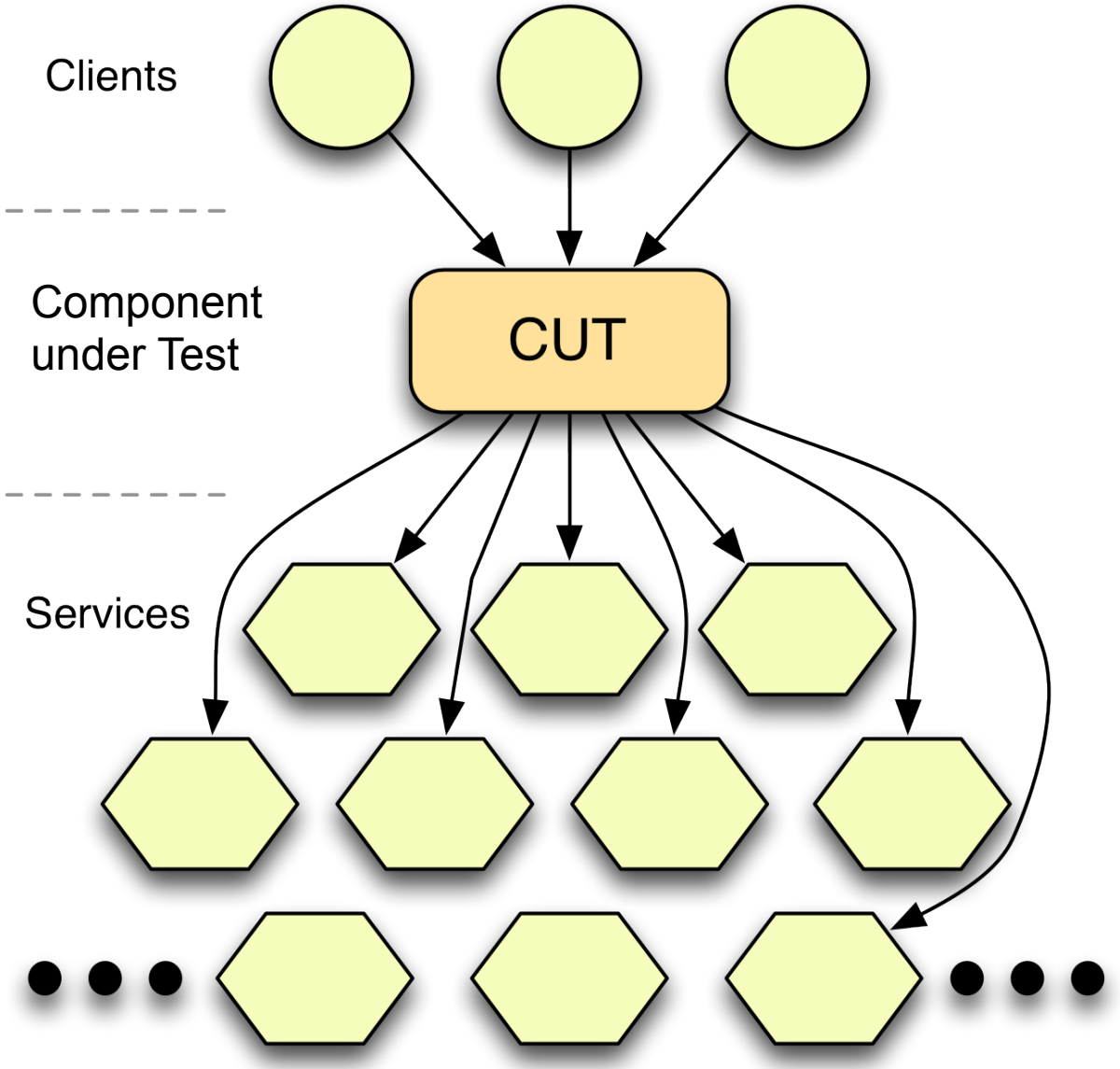
Enterprise Software Environments



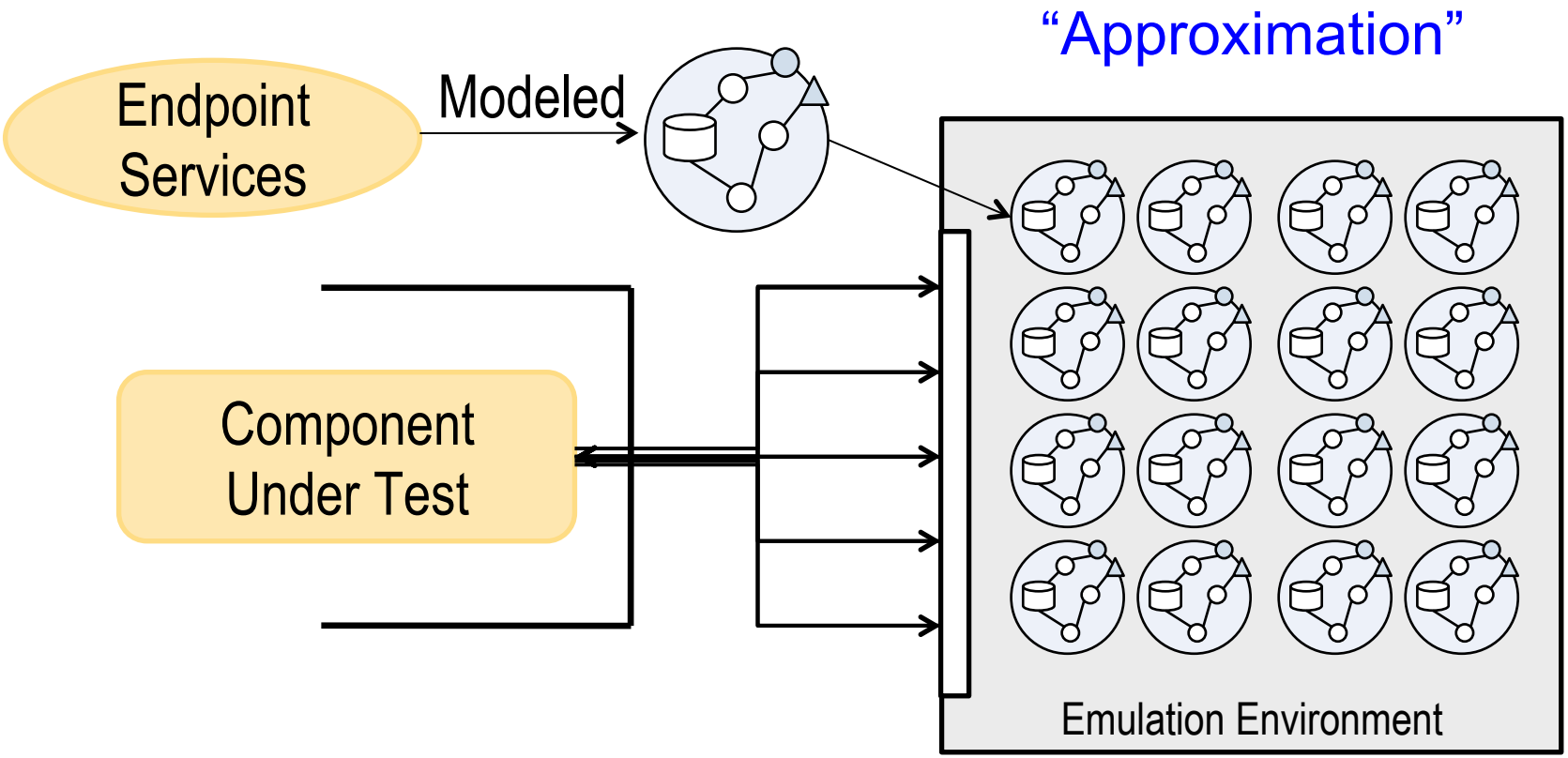
Clients and Services



Thousands of Endpoint Services



Environment Emulation



Approach - Emulation Environment

Scalability:

Lightweight models to ensure that *thousands* of endpoints may be emulated *on a single physical machine*

Heterogeneity:

Emulate as *many endpoint types* as needed for testing

Multiple Environment Instances:

Supply *different combinations* of models/configurations to emulation environment

Facilitate Evaluation Activities:

Record exact interactions between CUT and emulation environment

Runtime/playback visualization of interactions [ASE2012]

But how can we best generate executable endpoint models?

Endpoint Model Specification

In previous work:

- "programmatically" using a high-level programming language (e.g., Java, Haskell) [ASWEC2009, ASE2010]
- Too much "low-level" details to consider

High-level model creation

- Coloured Petri Nets (CPN) [QoSA2012]
- Non-trivial modeling of I/O structures

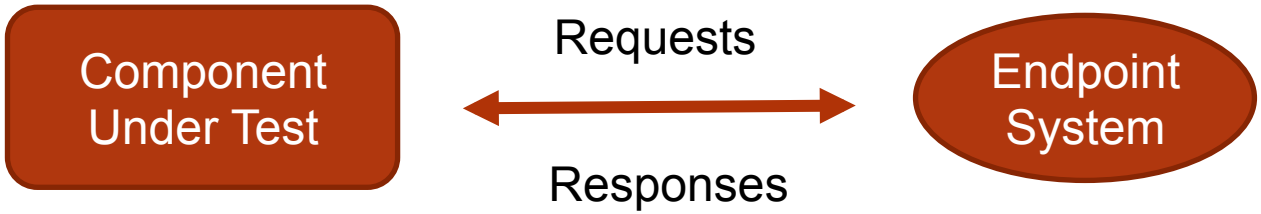
Model-driven

- (semi-)automatic generation from high-level protocol specification
- Endpoint behaviour still needs to be completed manually

Reliance on availability of protocol specifications

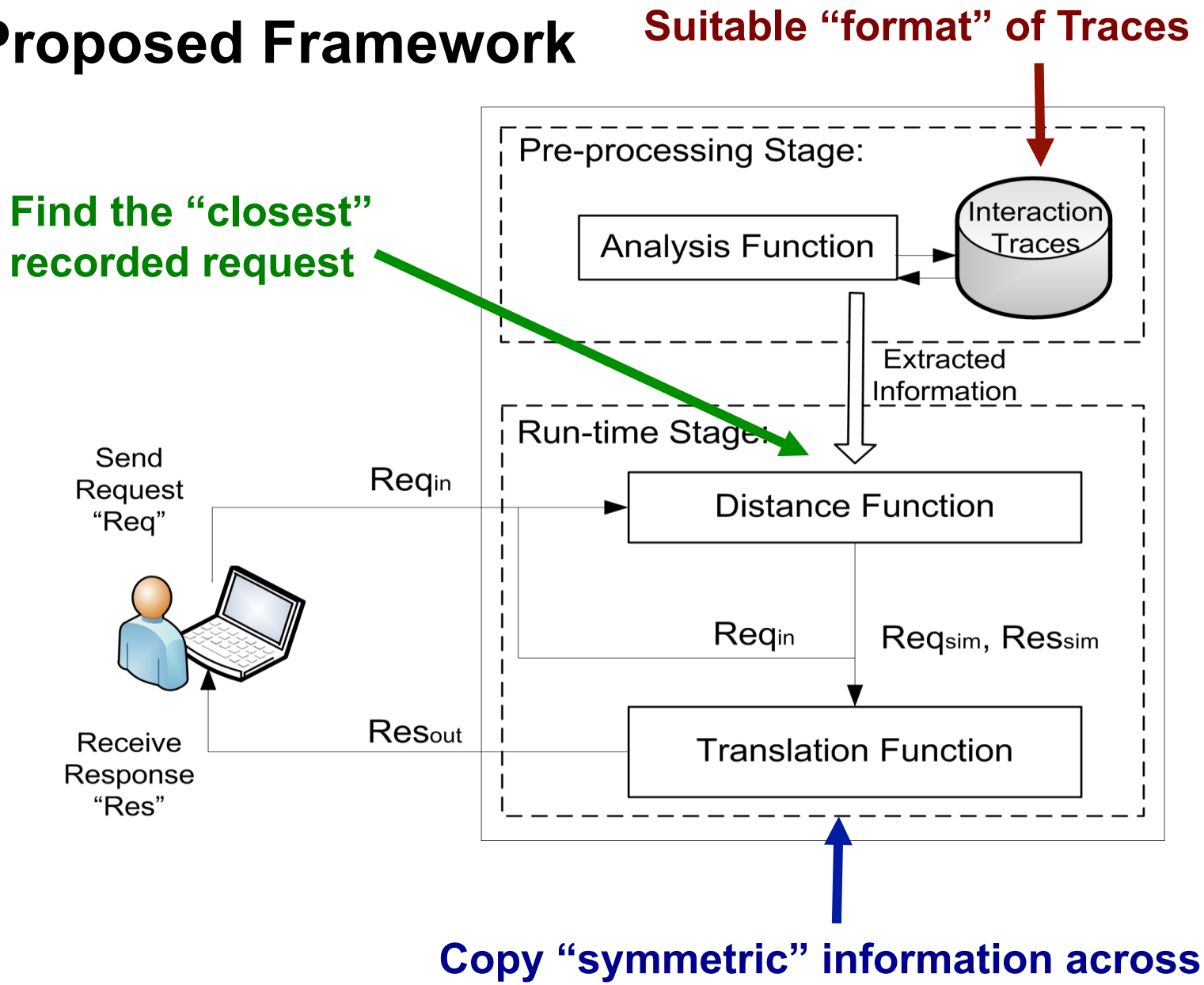
Significant Human Effort Required

Recording of Interaction Traces



- Observe and *record* the interaction between the Component Under Test and a “real” endpoint system.
  - ☞ If CUT not yet available, replace by system that uses the same protocol
- Assumption: interaction protocol defined by sequences of *request/response pairs*.
- Problem: recording is only a snapshot, but not a full protocol.

Proposed Framework



Assumption

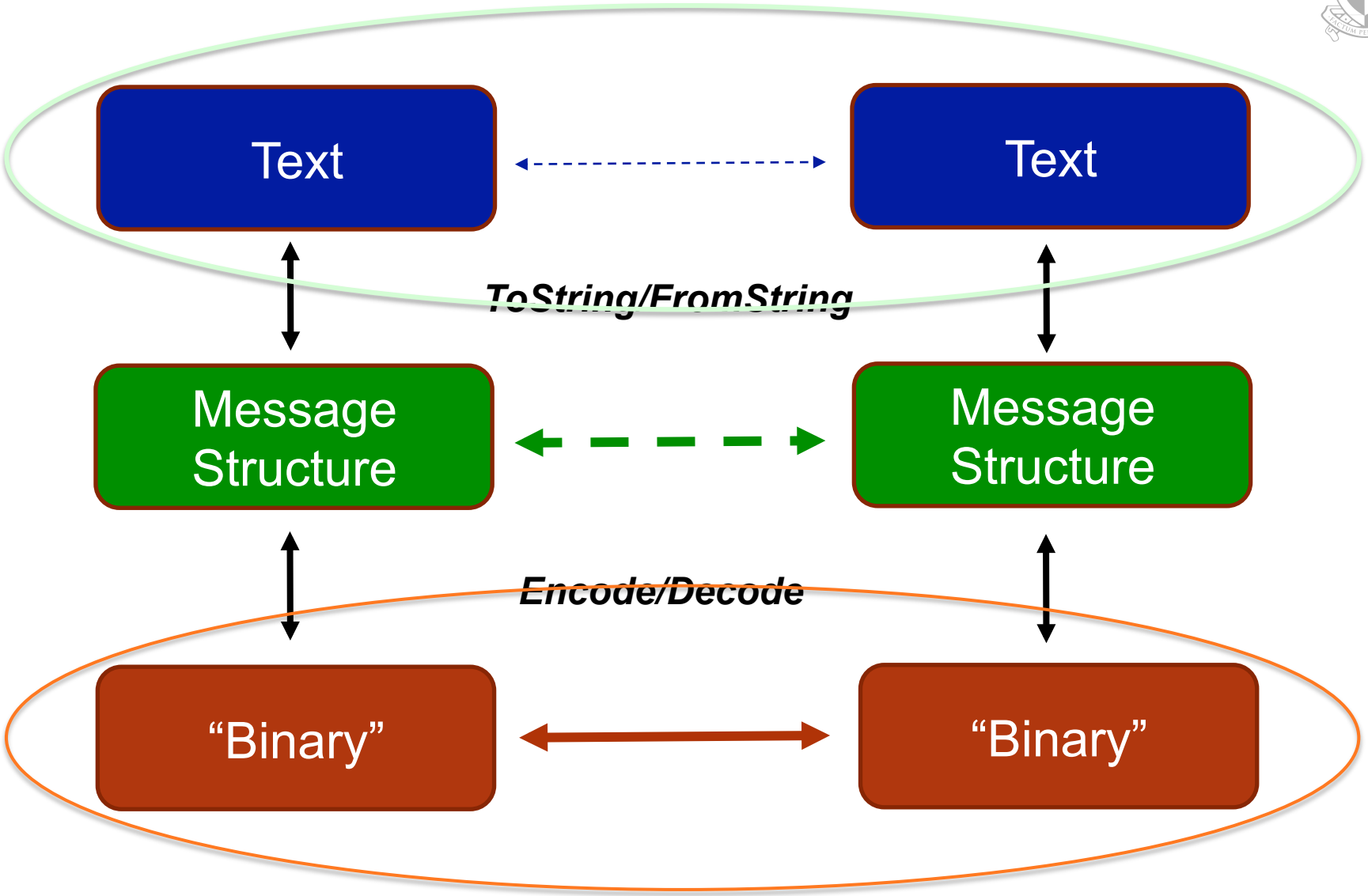
Having a suitable distance measure and a corresponding translator, “good enough” responses can be synthesized from pre-recorded interaction traces.

What level of abstraction to target?

What distance measure/translator to use?

How effective are they?

What Level of Abstraction?



Edit Distance as Distance Measure

Needleman-Wunsch algorithm *globally aligns* two sequences of elements. Commonly used in bioinformatics to align protein and/or nucleotide sequences.

Minimizes the “distance” between two sequences by inserting *gaps* at the right places.

“Normalized” Edit Distance as *dissimilarity* measure between two requests.

Sequence Alignment - Example

Two sequences

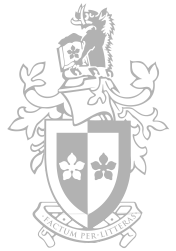
```
Where is my computer book?
Where is your computer magazine?
```

Alignment

```
Where is my___ computer book_________?
Where is _your computer ____magazine?
```

Result: distance = 16, dissimilarity = 0.28

“Symmetric Fields” – LDAP Example



LDAP request

Message ID: 37

ProtocolOp: searchRequest

ObjectName: cn=Michael SMITH, ou=Administration,
ou=Corporate,o=DEMOCORP,c=AU

Scope: 0 (baseObject)

Corresponding LDAP response

Message ID: 37

ProtocolOp: searchResEntry

ObjectName: cn=Michael SMITH, ou=Administration,o
ou=Corporate,o=DEMOCORP,c=AU

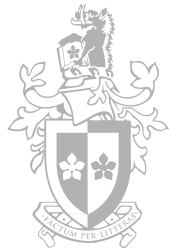
Scope: 0 (baseObject)

Message ID: 37

ProtocolOp: searchResDone

resultCode: success

LDAP – A Working Example



Incoming request

Message ID: 18
ProtocolOp: searchRequest
ObjectName: cn=Mal BAIL, ou=Administration,
ou=Corporate,o=DEMOCORP, c=AU
Scope: 0 (baseObject)

Generated response

Message ID: 18
ProtocolOp: searchResEntry
ObjectName: cn=Mal BAIL,ou=Administration,
ou=Corporate,o=DEMOCORP,c=AU
Scope: 0 (baseObject)
Message ID: 18
ProtocolOp: searchResDone
resultCode: success

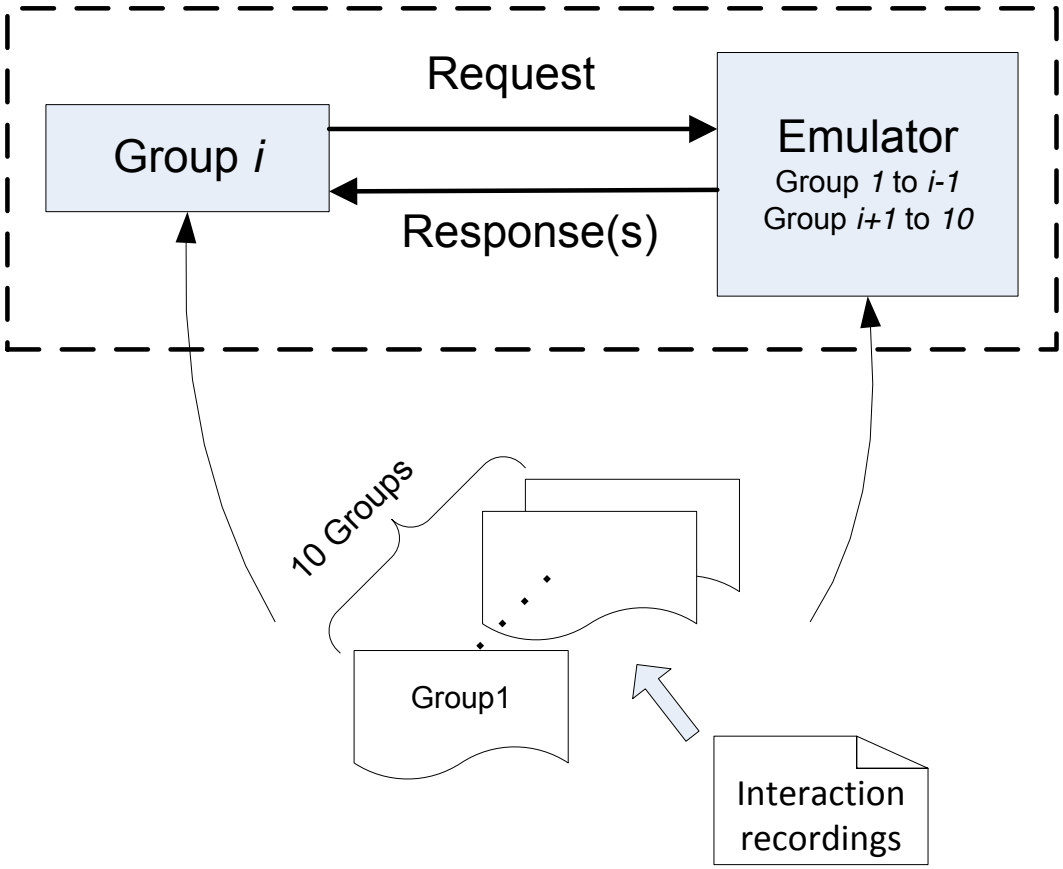
"Best" matching request

Message ID: 37
ProtocolOp: searchRequest
ObjectName: cn=Michael SMITH,ou=Administration,
ou=Corporate,o=DEMOCORP,c=AU
Scope: 0 (baseObject)

Associated response

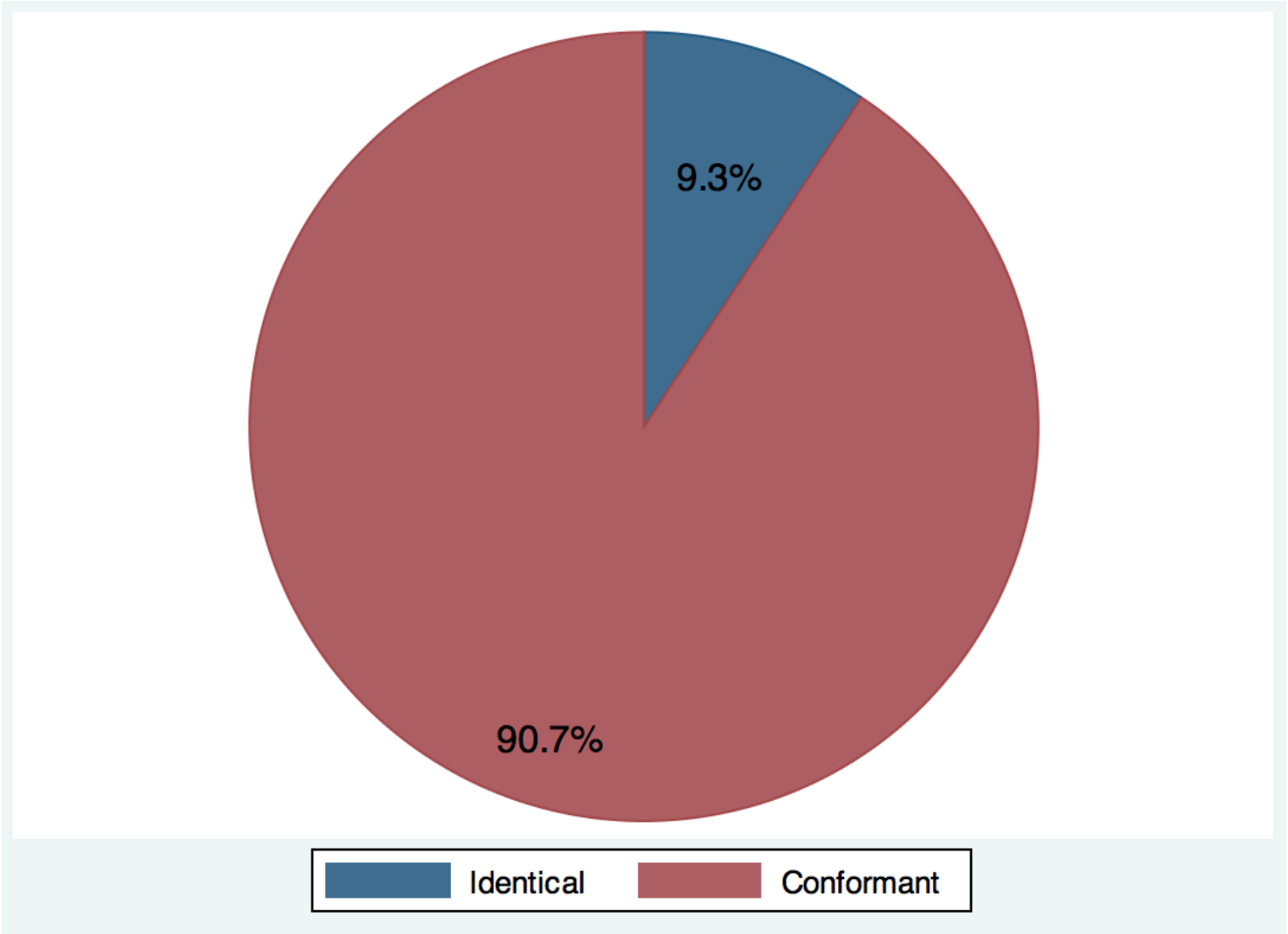
Message ID: 37
ProtocolOp: searchResEntry
ObjectName: cn=Michael SMITH,ou=Administration,
ou=Corporate,o=DEMOCORP,c=AU
Scope: 0 (baseObject)
Message ID: 37
ProtocolOp: searchResDone
resultCode: success

Evaluation

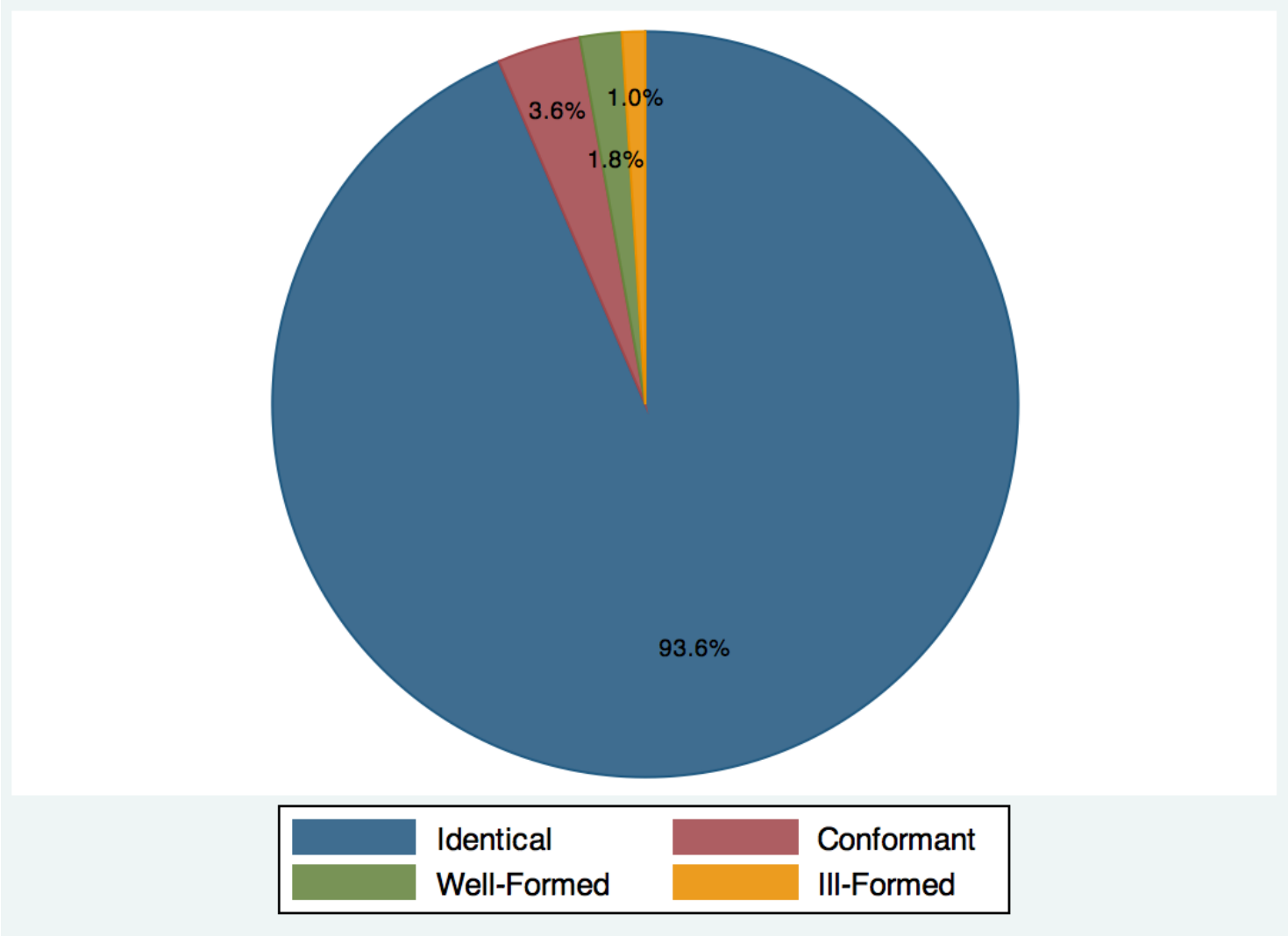


10 fold Cross-Validation using LDAP (498 request/response pairs) and SOAP (1000 request/response pairs)

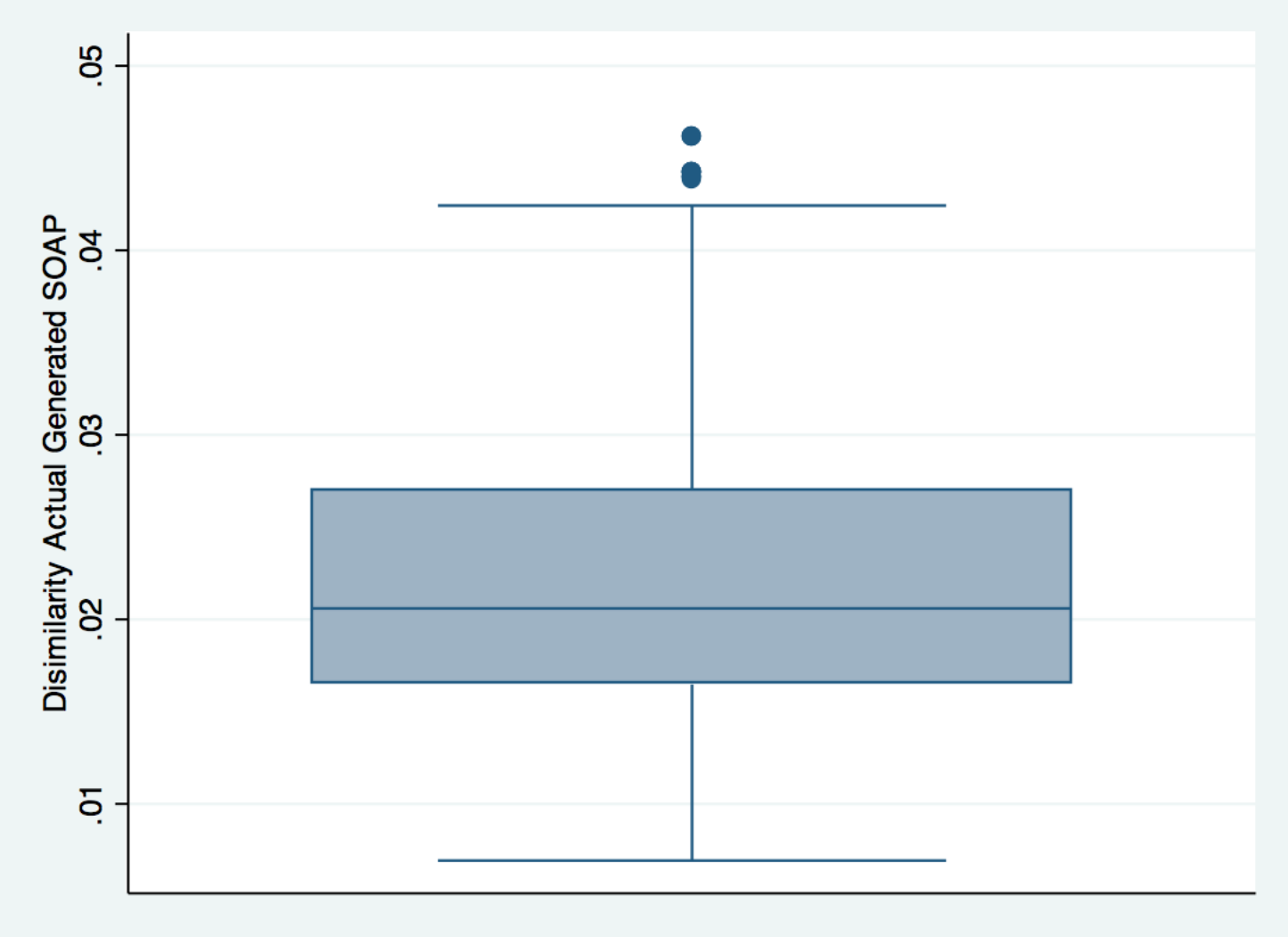
Results – SOAP Evaluation



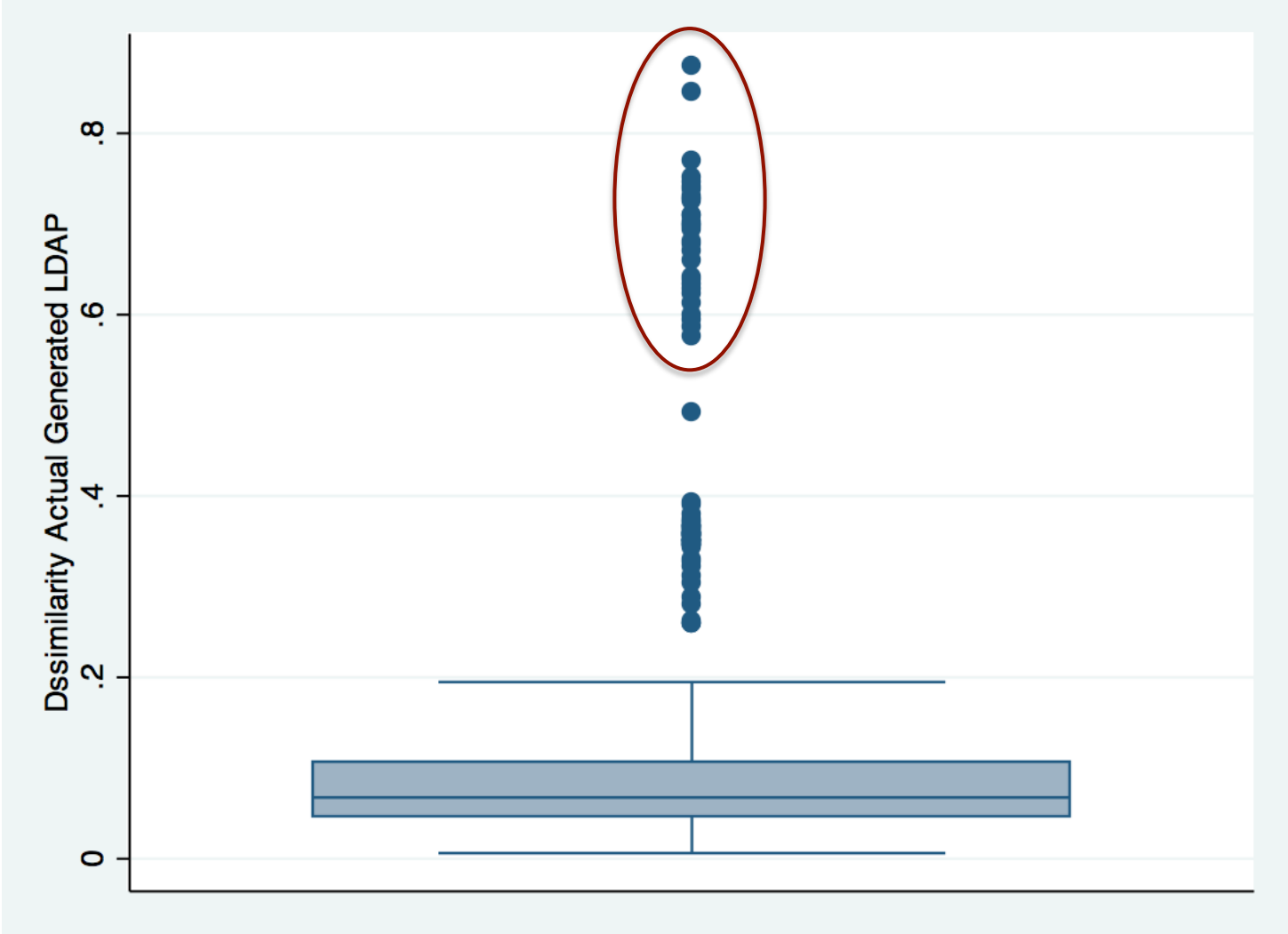
Results – LDAP Evaluation



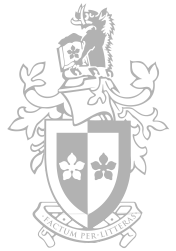
Results – SOAP Dissimilarities



Results – LDAP Dissimilarities



Discussion and Conclusions



- Interaction Traces a promising approach to generate responses to incoming requests
  - Basic approach works for the chosen protocols
  - 99% “good enough” responses
- Avoid human effort in specifying executable endpoint models
  - shift towards framework configuration
- Lack of:
  - “temporal” properties of interaction protocols
  - support for “write” operations
  - consideration of “operation names”

Future Work

- Extend evaluation to more/different kinds of protocols (e.g., ReST, CAM/CAFT, BitTorrent)
- Differentiate structure and payload
- Partitioning of recorded interaction traces
  - ☞ Improve efficiency and accuracy
- Consider “temporal” protocol properties
- Different distance measures (e.g., tree distance) and translators
- Explore framework at binary level
- Hook into existing emulator

Acknowledgements

This work is supported by the Australian Research Council (ARC) Linkage project "*Large-Scale Emulation for Enterprise Software Systems*".

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ca technologies

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