Modelling and Verification of Layered Security Protocols: A Bank Application

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A Need for Security

Society and economies rely on computer networks for communication, finance, energy distribution, transportation...

Attacks threaten economical and physical integrity of people and organizations.

Interconnected systems can be attacked anonymously and from a safe distance.

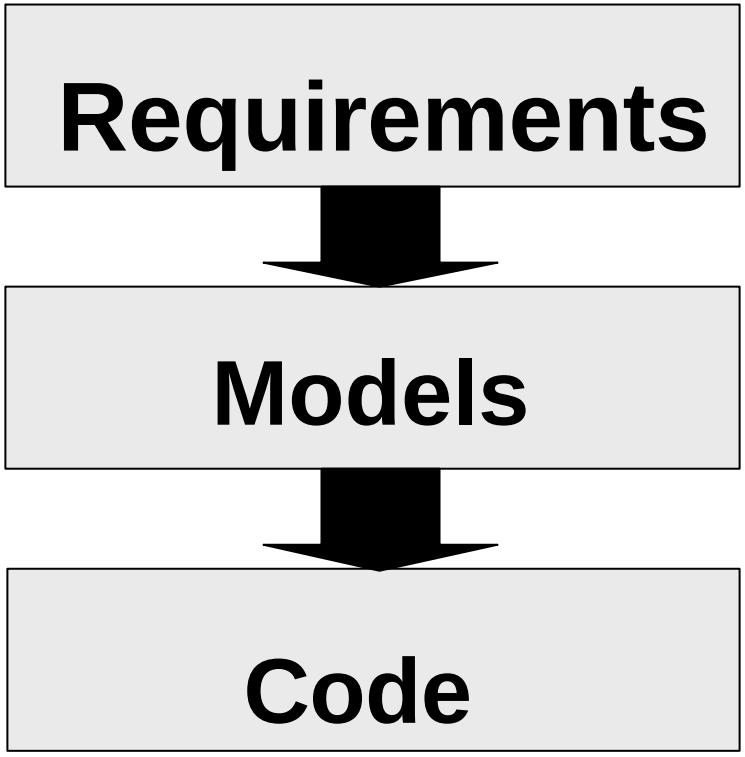
Networked computers need to be secure.

Need secure software engineering.

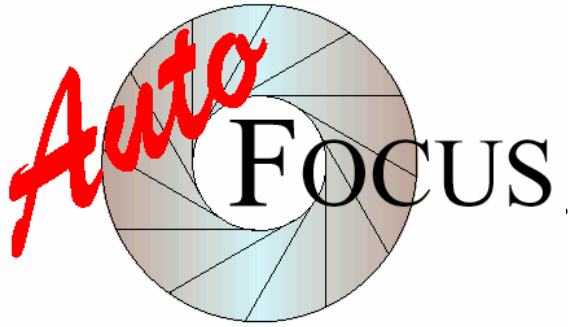
Model-based Development

Goal: easen transition from human ideas to executed systems.

Increase quality with bounded time-to-market and cost.



AutoFocus



CASE-Tool with formal basis

Graphical, view oriented modelling (UML-like).

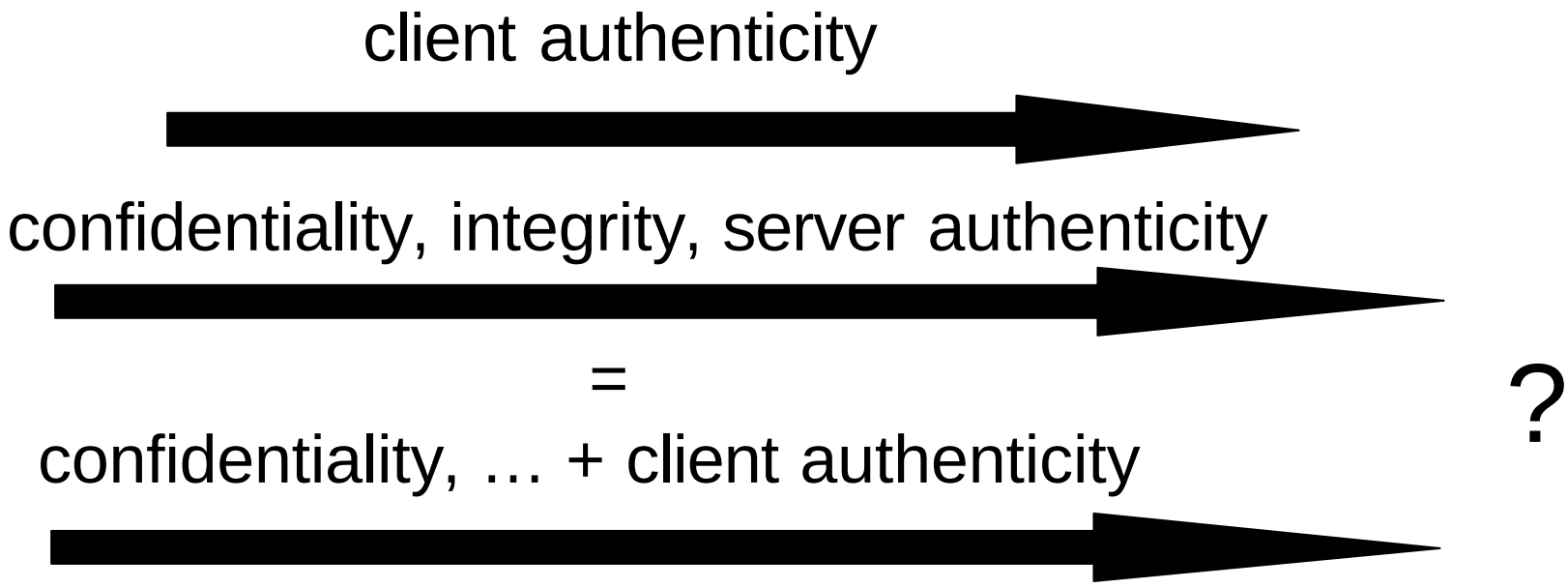
- System Structure Diagrams.
- State Transition Diagrams.
- Message Sequence Diagrams.
- Data Type Definitions.

Features:

- Simulation.
- Validation (Consistency, Testing, Model Checking).
- Code generation (e.g. Java, C).

Layered Security Protocols

- Protocol on higher layer uses services of protocol on lower layer.
- Big question: security properties additive ?
- Desirable: secure channel abstraction.



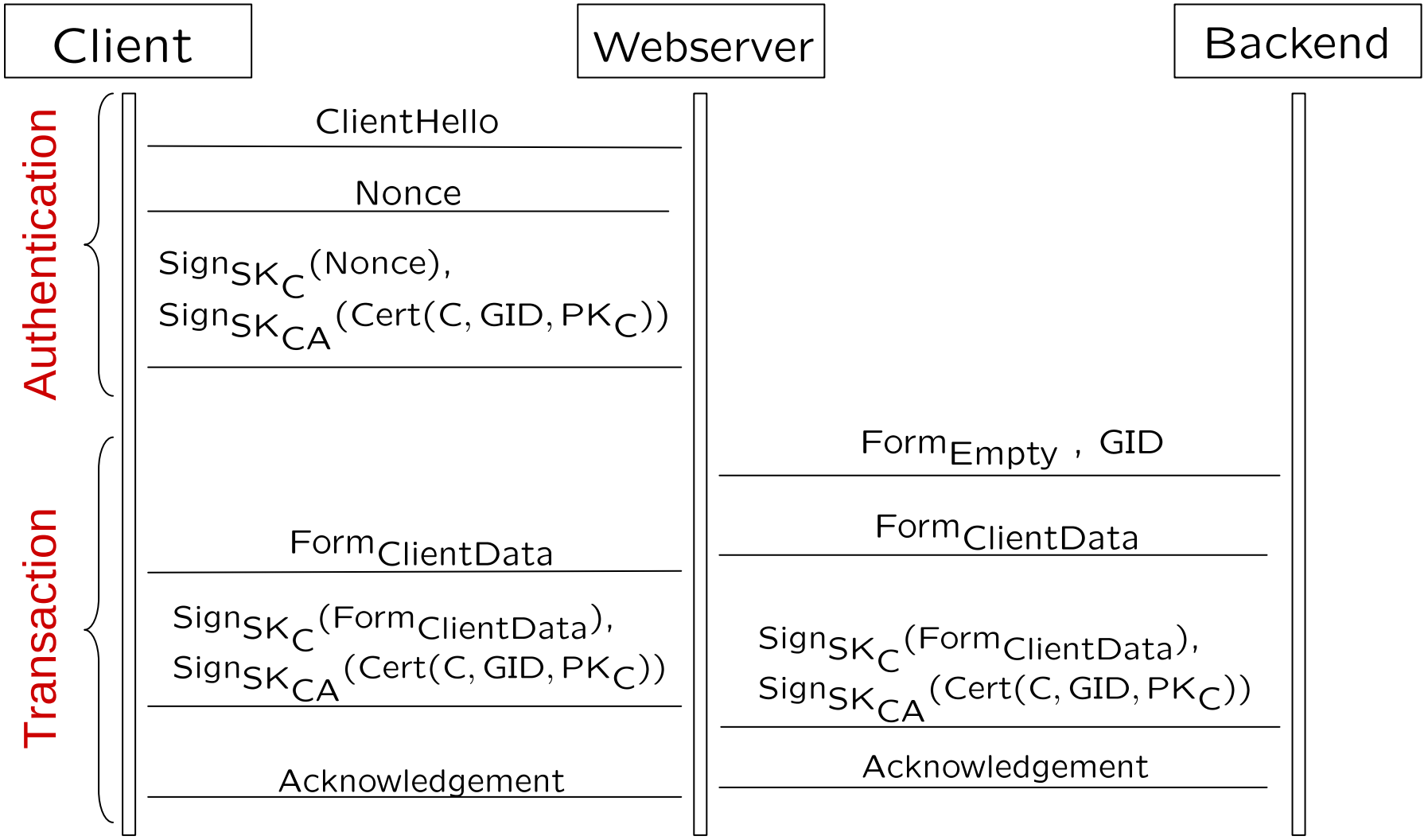
Here: Bank application

- Security analysis of web-based banking application, to be put to commercial use (clients fill out and sign digital order forms).
- In cooperation with major German bank.
- Layered security protocol
  - first layer: SSL protocol.
  - second layer: client authentication protocol
- Main security requirements:
  - personal data confidential.
  - orders not submitted in name of others.

The Application II

- Two layer architecture.
- When user logs on, an SSL-connection is established (first layer).
  - Provides secrecy, integrity, server authentication but no client authentication (this version).
- Custom-made protocol on top of SSL for client authentication.
- Session key generated by SSL used to encrypt messages on second layer.

Authentication protocol



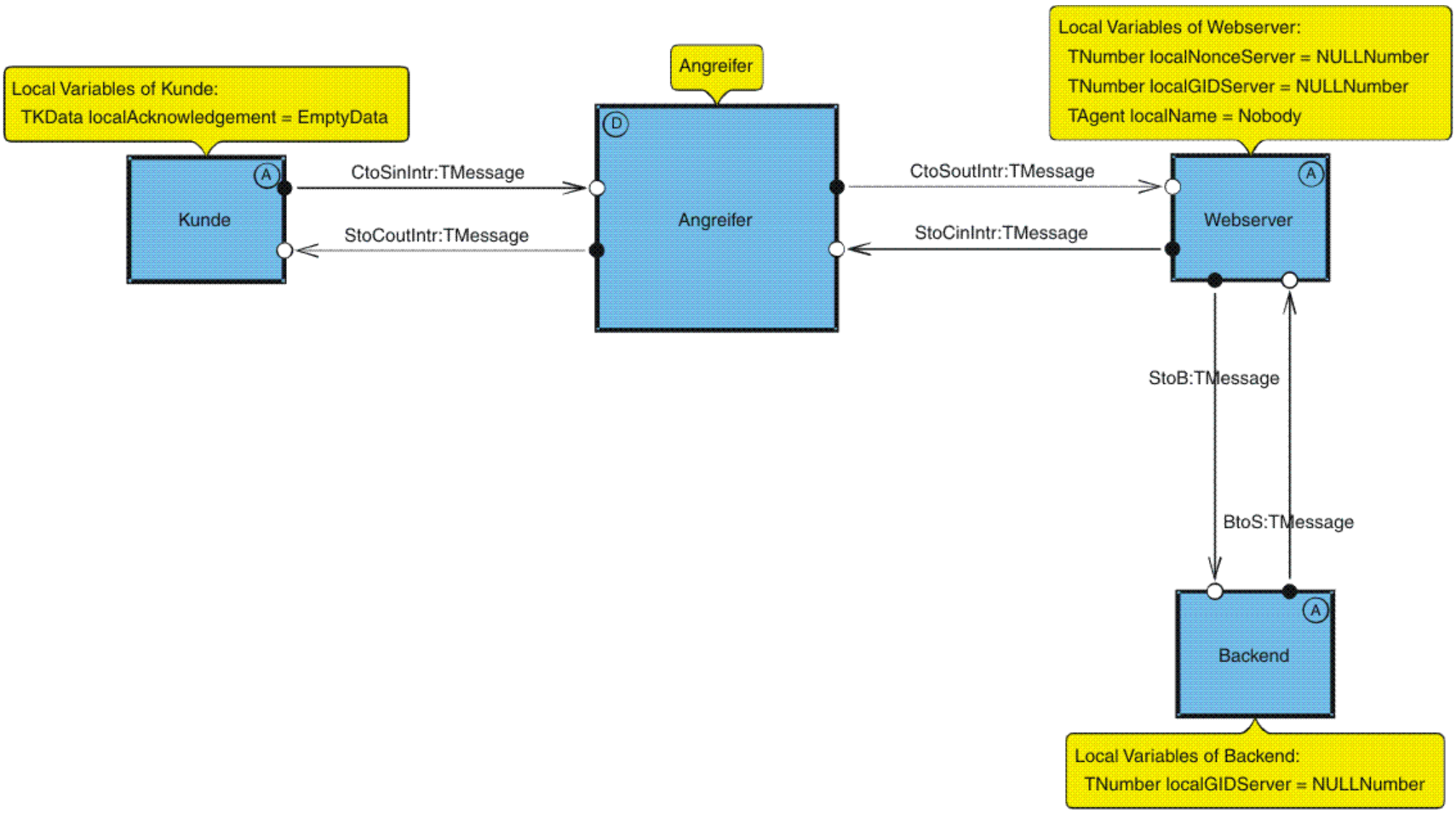
Generic Adversary (Dolev-Yao)

- May know some data in advance (but not private keys etc.).
- Can read, modify, split, recombine, insert and delete messages.
- Not able to derive private key from public key.
- Can only read encrypted messages with the corresponding key.
- Cannot break encryption, fake signatures etc.
- Cannot perform statistical attacks.

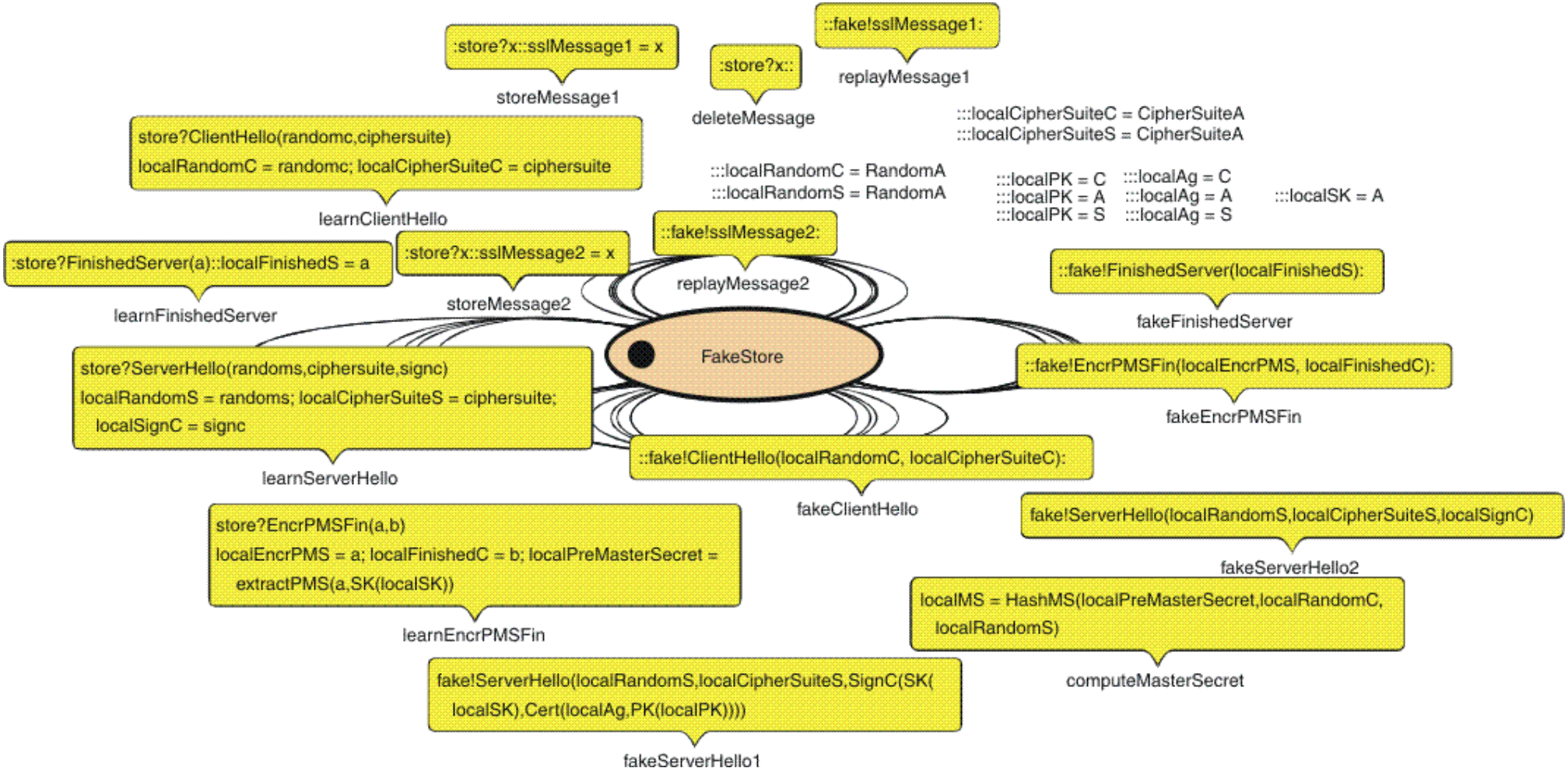
Layered Security Protocol

- Adjust adversary model to account for SSL security properties.
- Justify that specialised adversary model wrt. top-level protocol is as powerful as generic adversary wrt. protocol composition.
- Verify top-level protocol wrt. specialised adversary.
- Implies verification of protocol composition.

SSD Overview



Part of generated adversary model



Verification of the Auth. protocol 1

- Authentication:
  - It's not possible for the adversary to authenticate under a wrong identity against the web server.

$$\neg(\mathbf{E}(\neg\text{Client in state } \mathit{SentNonceCert}\ \mathbf{U}\ (\text{Webserver in state } \mathit{GotSignedNonce} \wedge \text{nonce was signed Client})))$$

  - Used time: approx. 2 hours 40 minutes.

Verification of the Auth. protocol 2

- Transaction:
  - It's not possible for the adversary to get the confidential client's data.

$$\mathbf{AG}\ ((\textit{FakeStore}\ \text{doesn't get the GID}) \wedge (\textit{FakeStore}\ \text{doesn't get the Client's data}) \wedge (\textit{FakeStore}\ \text{doesn't get the acknowledgement}))$$

  - Used time: approx. 2 hours 50 minutes.

Conclusion & Future work

Protocol layering indeed additive wrt. security properties in this particular case.

Future work: Generalize to classes of protocols and security.

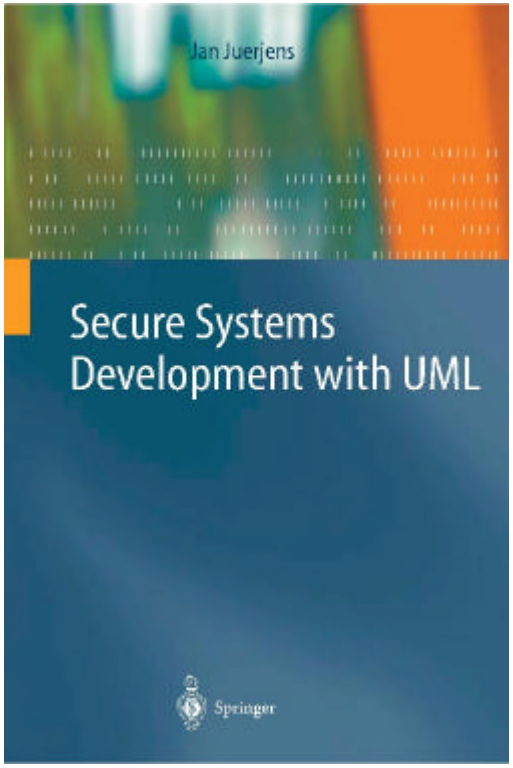
Some resources

Book: Jan Jürjens, Secure Systems Development with UML, Springer-Verlag, due 2003

Tutorials: Sept: FORTE (Berlin); Oct: GI Sicherheitstagung (Frankfurt), ASE (Montreal), SNDP (Lübeck), LADC (Sao Paulo); Nov: WWW/Internet (Algarve), FMOODS (Paris), ICSTEST-E (Bilbao) …

Special SoSyM issue on Critical Systems Development with UML

CSDUML'03 @ UML'03 conference (Oct. in SFO)



More information (slides, tool etc.):
http://www4.in.tum.de/~juerjens