Next Generation LearnLib **(NGLL)**

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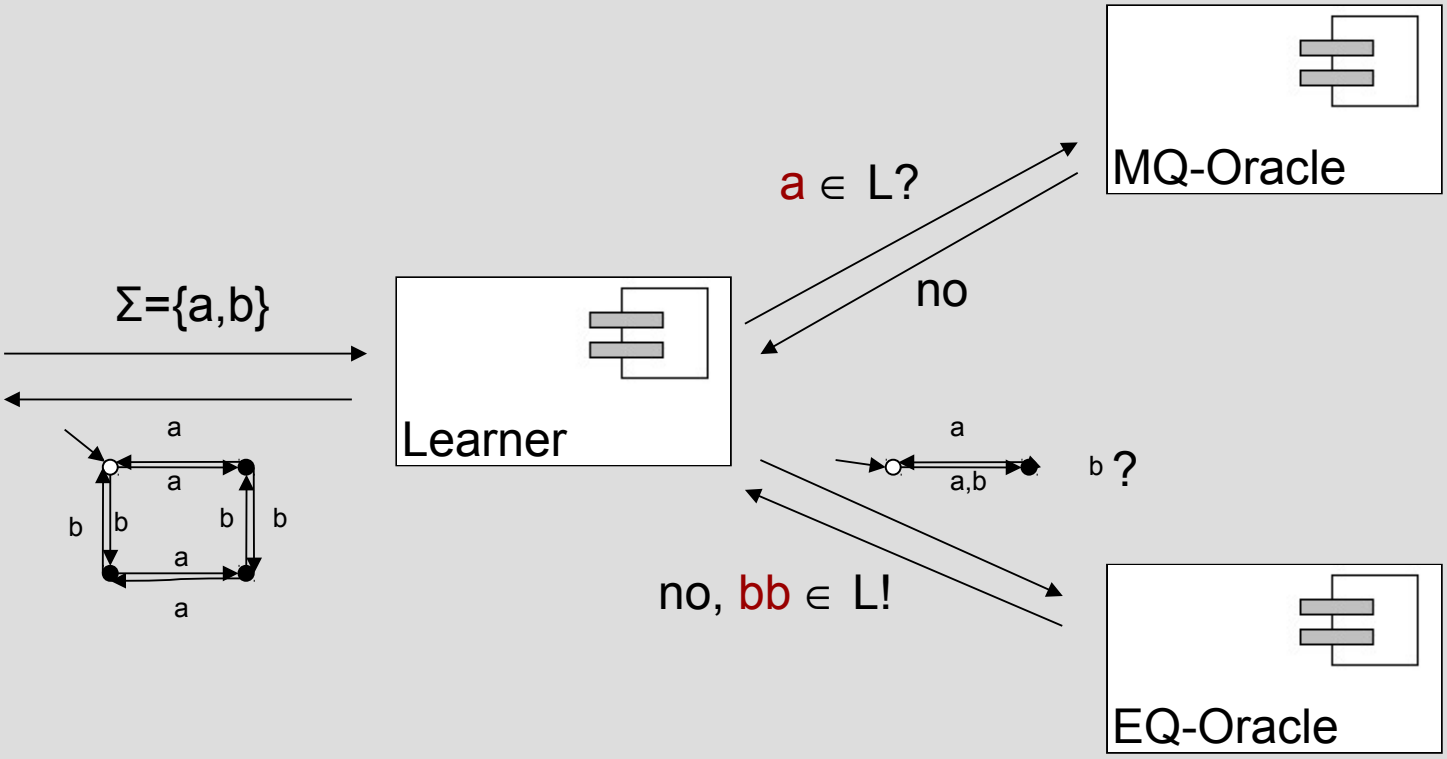
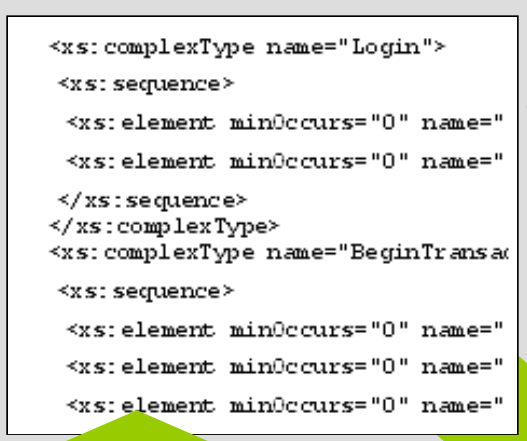
Overview

- **Practical aspects** in active automata learning
- LearnLib: mature library for **active atomata learning**
- NGLL: framework, providing **infrastructure** for practical application
- Tool-demo: **Modeling** learning setups with LearnLib & LearnLib Studio

Active automata learning



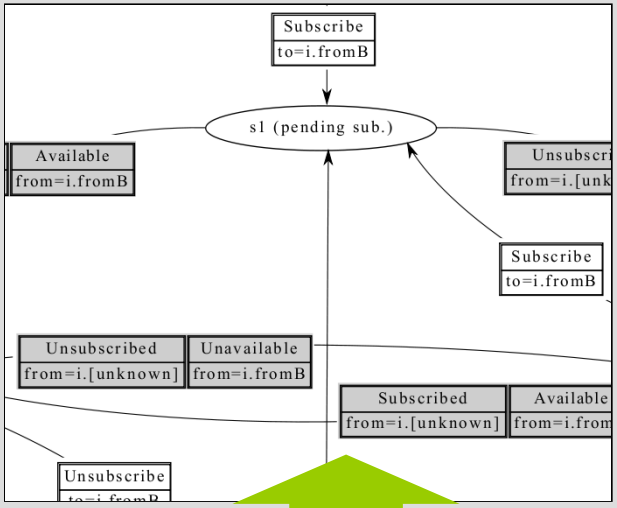
Practical challenges



Interface description

etc.

interfacing real systems:
- alphabet generation
- abstraction
- data



equivalence queries

Behavioral models

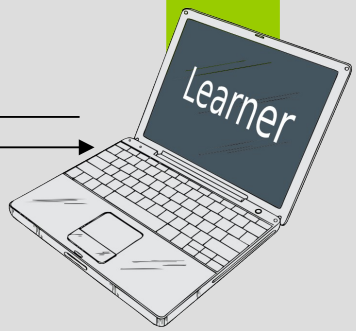
<presence type=… />

<iq type= “result“ />

Test-driver

Available

OK



membership queries

reset

NGLL: Structure & components

Algorithms (LearnLib)
- Learning algorithms
- Counterexample analysis
- Equivalence query realizations

Core/Utils (LearnLib)
- (Small) automata library
- Statistics
- Logging
- Import/export (dot, ppt, xml etc.)
- Simulation environments

Case studies (NGLL)
- Test-driver tools
- Data mappers
- Abstraction

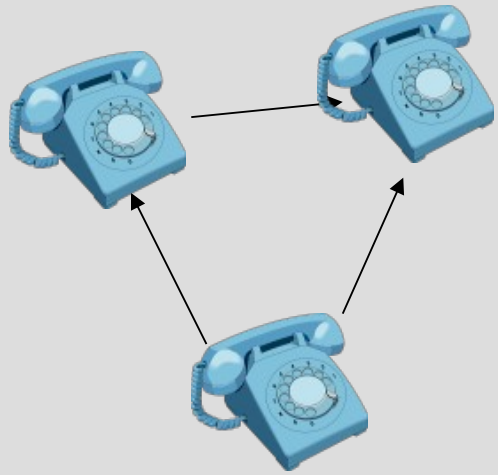
LearnLib Studio (NGLL)
- Visual composition of learning experiments

LearnLib: Algorithms

- **Learning algorithms**
  - Angluin's L*
  - Rivest and Schapire's "Reduced Observation Table"
  - Non-uniform observation table
  - DHC
- **Handling Counterexamples**
  - Maler and Pnueli
  - Shahabaz and Groz
  - Rivest and Schapire
- **Equivalence queries**
  - Chow's "W-Method"
  - Random walks
  - Hopcroft and Karp
  - Evolving hypothesis

All algorithms work for DFA + Mealy machines

LearnLib: Enhancements



- **POTS with 3 parties (CADP)**
- 39.979 states
- > 2 million transitions
- > 270 equivalence queries

Old c++ LearnLib (2009)

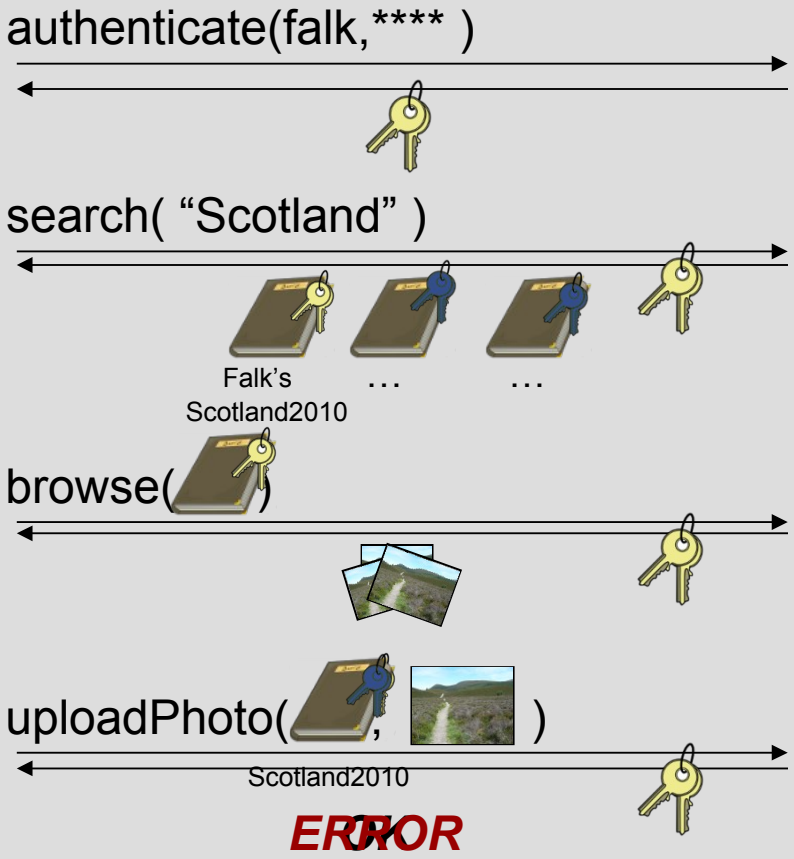
- 3 hours
- 7GB memory
- > 690 million MQ

Java NGLL (today)

- 20 minutes (-90%)
- 2,3GB memory (-60%)
- ca. 593 million MQ (-15%)

NGLL: Test-drivers (example)

A photo service

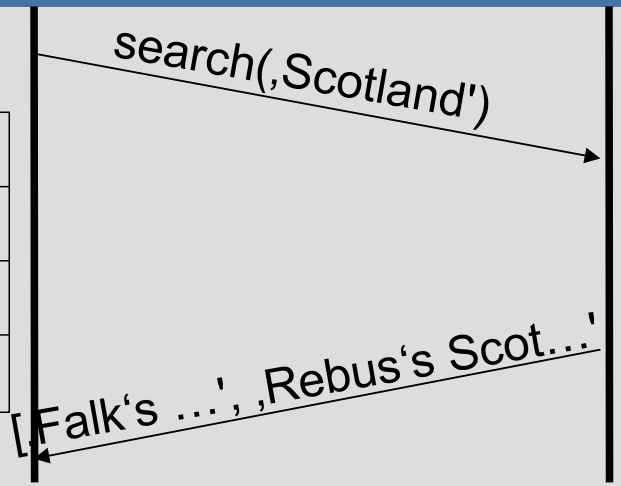


register(…
createAlbum(…
getAlbum(…

Beyond plain DFA / Mealy machines

PhotoService Client

session	ssid-123
albums	[‚Fa…',
:::	

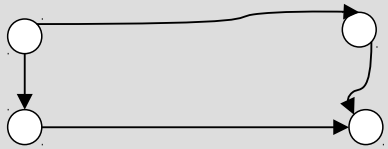


PhotoService

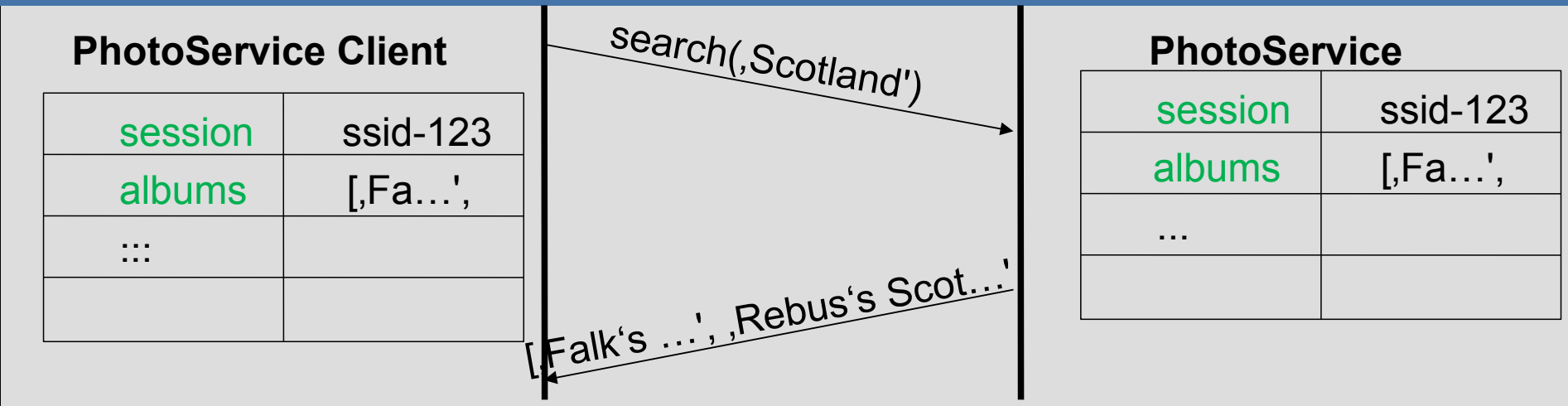
session	ssid-123
albums	[‚Fa…',
...	

albums = search(si, query)

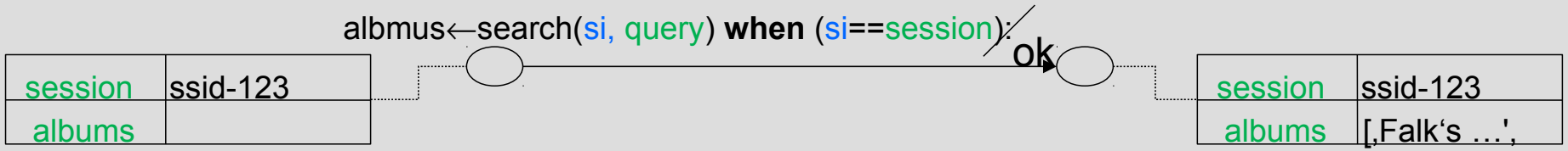
```
search(si):
   if (si == session)
      return matchingAlbums(query);
```



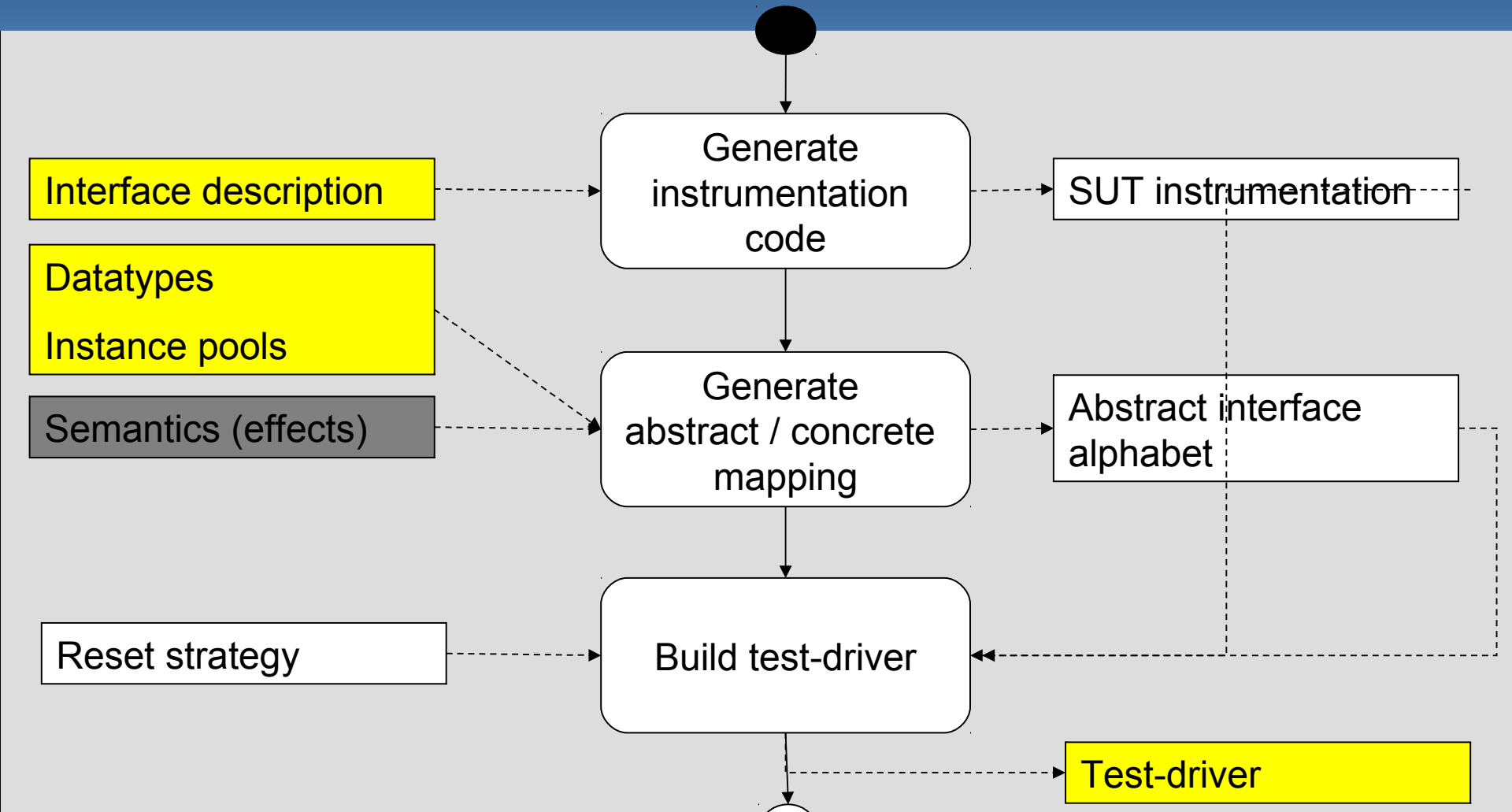
Beyond plain DFA / Mealy machines



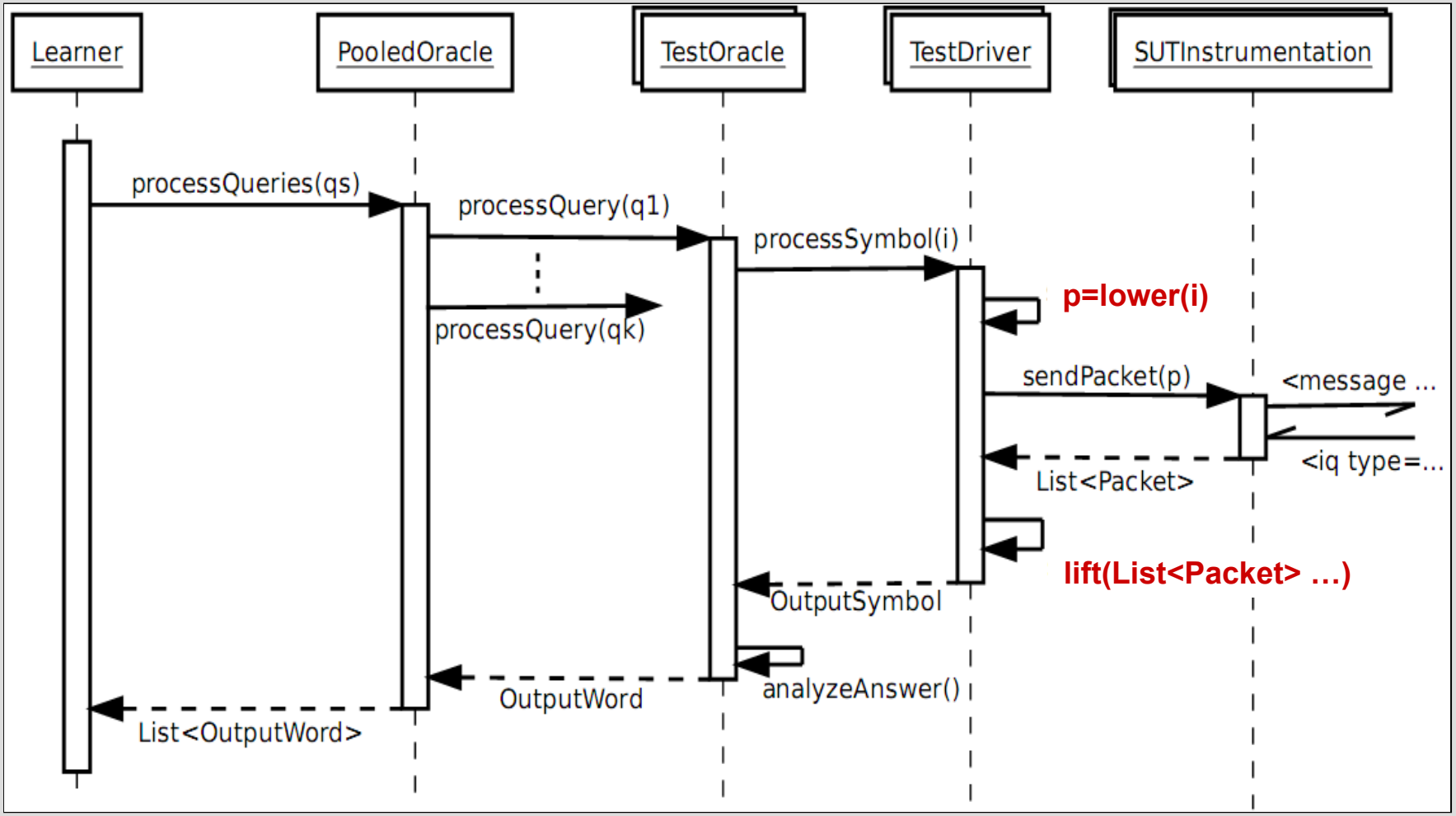
Symbolic Mealy machines with registers:



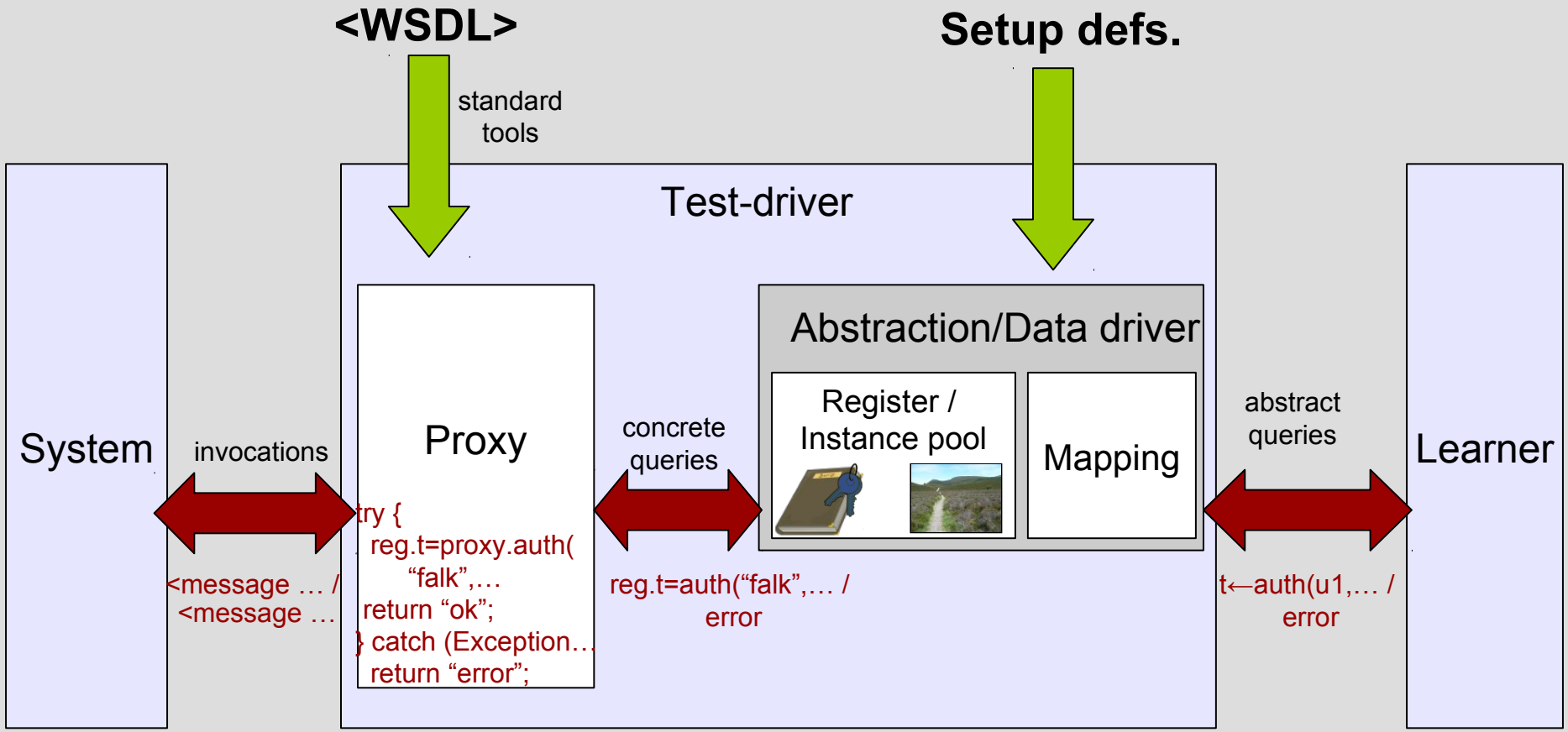
Building test-drivers



Test execution



Generating test-drivers from WSDLs



Summary

- **LearnLib:** mature library for active automata learning
- **NGLL:** Infrastructure to learn real systems
- **LearnLib Studio:** visual composition / debugging of learning experiments

- www.learnlib.de

Hands on …

Tool demo

Example: SendAGift24.com

Post-mortem analysis of a legacy service

Scenario

```
/**
 * This is the interface to SendAGift24.com
 *
 * SendAGift24 is a multi-billion .com that is specialized in providing
 * a service where people can shop gifts for friends.
 *
 *
 * Sadly all system backups disappeared into the cloud, so the service
 * source code was retrieved by decompiling obfuscated binaries. I wonder if
 * there is a technology to find out how this service works.
 *
 * The CEO of the company told me that "user" and "password" are fitting
 * credentials, so at least security is up to modern standards.
 */
public interface Service {

    public long a(String a, String b) throws Exception;

    public String[] b(long l) throws Exception;

    public Object[] c(long l) throws Exception;

    public boolean d(long l, String s, Object o) throws Exception;
}
```

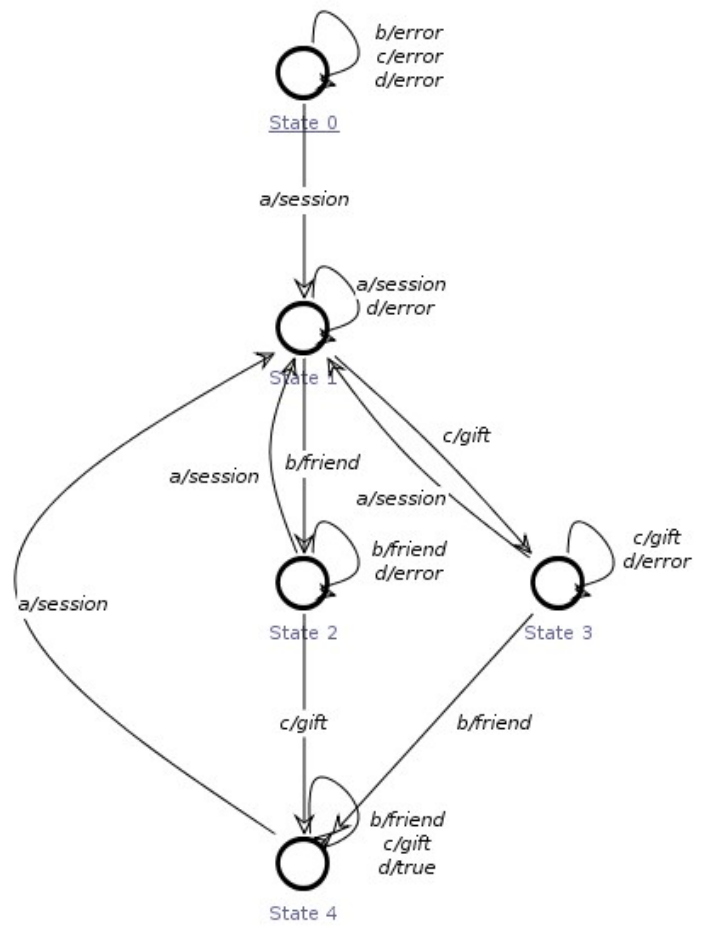
Test-driver design

- Handle data-dependencies
  - instance-pool for, e.g., credentials
  - store invocation results of previous invocations for inter-method dependencies
  - fill in parameters from data store
- Translate learning symbols into concrete invocations
- Lift concrete system output, lower abstract parameters
- Ensure every query is executed on initial state

Implementation

- `sendagift.learner.ServiceAlphabet`
  - alphabet of abstract symbols
    - can be used with AddAlphabetByClassName SIB
- `sendagift.learner.ServiceDriver`
  - application-specific test-driver
- `sendagift.learner.ServiceOracle`
  - glue between learner and test-driver
    - can be used with QueryOracleByClassName SIB

Learned result



- a == openSession
- b == getFriends
- c == getGifts
- d == sendGift
- gift and friend have to be known before sendGift can be invoked
- friend and gift bound to session