University of Duisburg-Essen, Institute for Experimental Mathematics

An Introduction to Reliable Server Pooling and the *RSPLIB* Implementation

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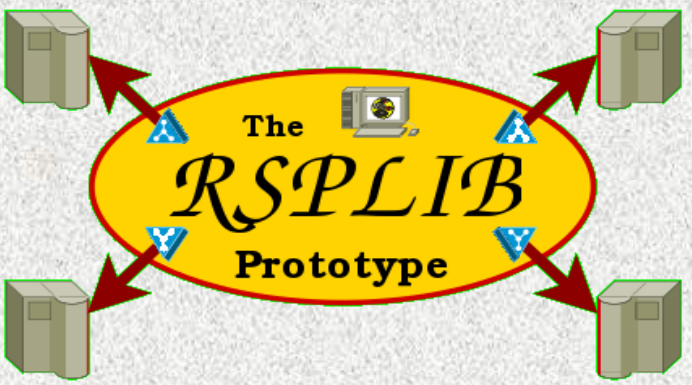

Thomas Dreibholz's Reliable Server Pooling Page
http://tdrwww.exp-math.uni-essen.de/dreibholz/rserpool/

Motivation (I)

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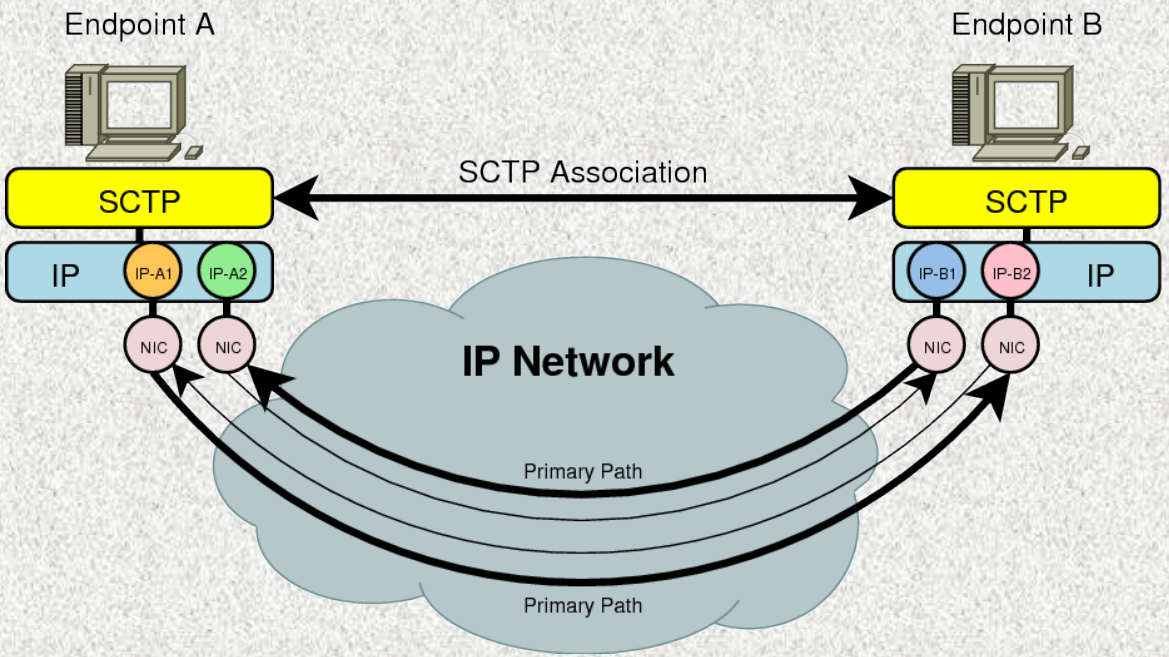
- Original Motivation:
  - Telephone signalling (SS7 protocol) over IP networks
  - Strict requirements on availability
- The Stream Control Transmission Protocol (SCTP) [RFC 2960]
  - „TCP Next Generation“
  - **Multi-Homing**
  - Add-IP: dynamic address reconfiguration
  - Multi-Streaming
  - Message-Framing
  - Protection against DoS
    - 4-way handshake
    - „Verification Tag“



- SCTP protects against various network problems, but ...
- ... not against a **server failure**

⇒ Concept for **server redundancy** is **required**

Motivation

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- Motivation of Reliable Server Pooling (RSerPool):
  - Unified, application-independent solution for service availability
  - Not available before => Foundation of the IETF RSerPool Working Group
- Application Scenarios for RSerPool:
  - Main motivation: **Telephone Signalling (SS7) over IP**
  - Under discussion by the IETF:
    - **Load Balancing**
    - Voice over IP (VoIP) with SIP
    - IP Flow Information Export (IPFIX)
  - ... and many more!
- Requirements for RSerPool:
  - **“Lightweight”** (low resource requirements, e.g. embedded devices!)
  - **Real-Time** (quick failover)
  - **Scalability** (e.g. to large (corporate) networks)
  - **Extensibility** (e.g. by new server selection rules)
  - **Simple** (automatic configuration: “just turn on, and it works!”)

Related Research Areas

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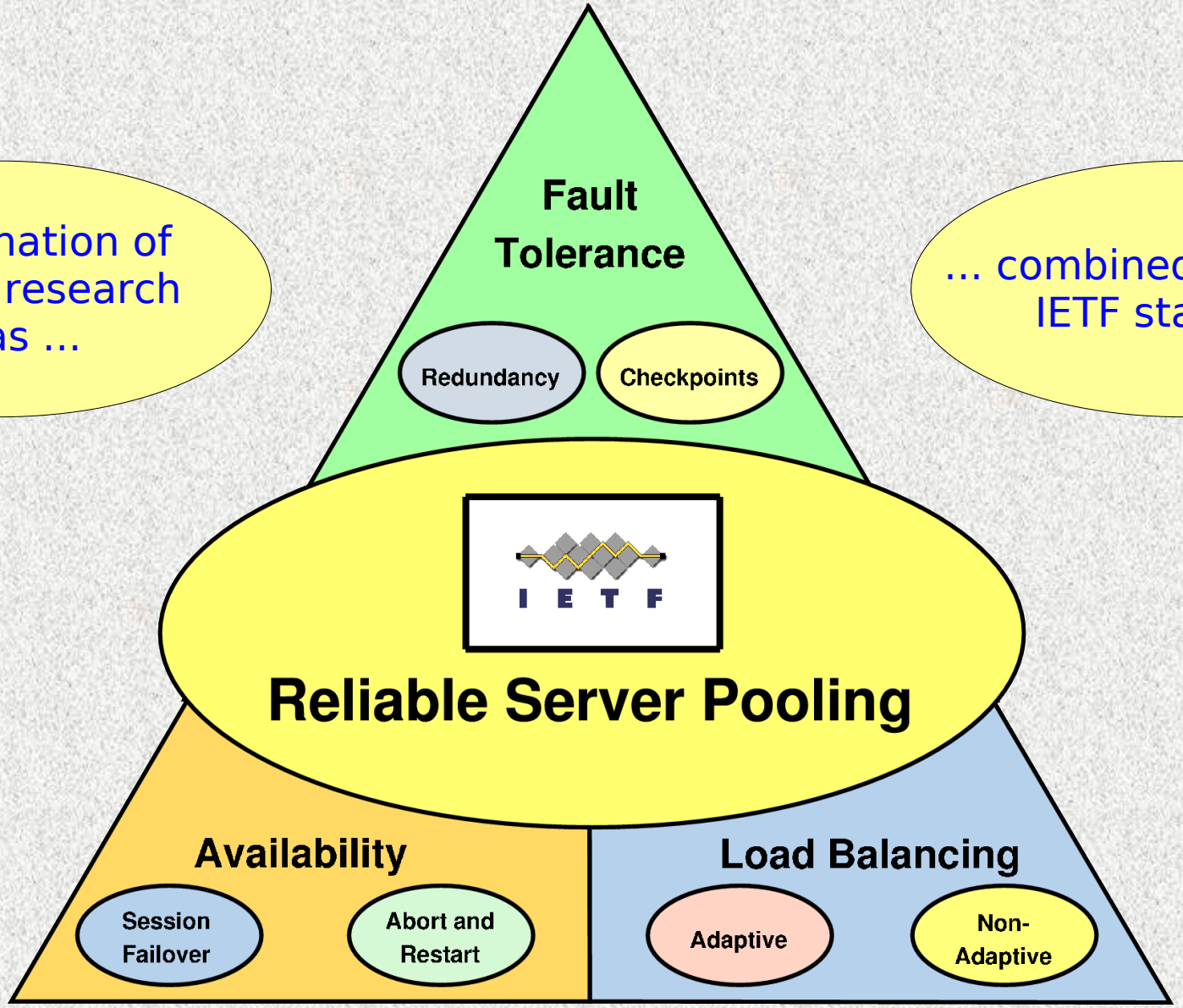
A combination of different research areas ...



... combined into a new IETF standard!

What is „Reliable Server Pooling“? Prototype Demonstration

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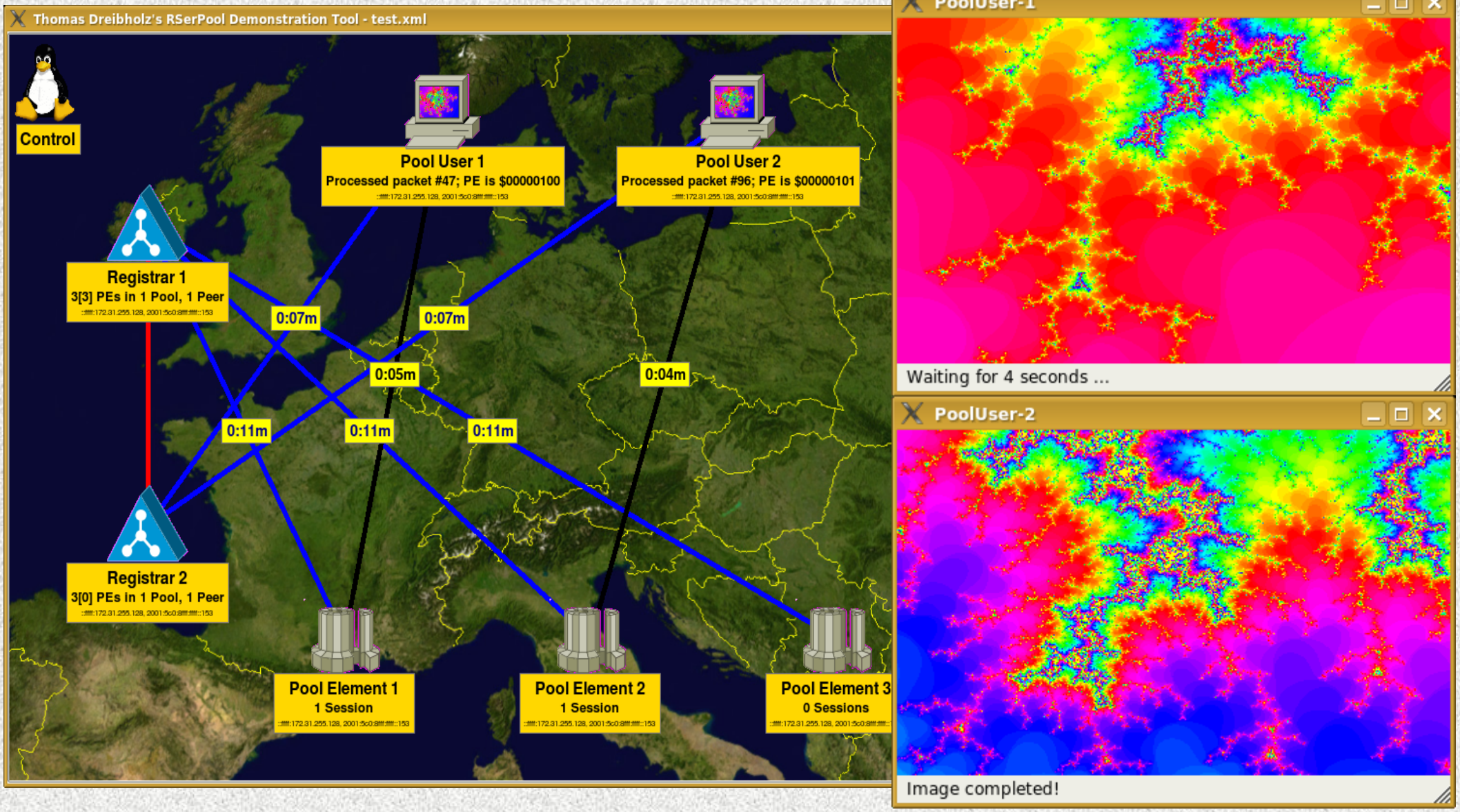

Reliable Server Pooling (RSerPool)

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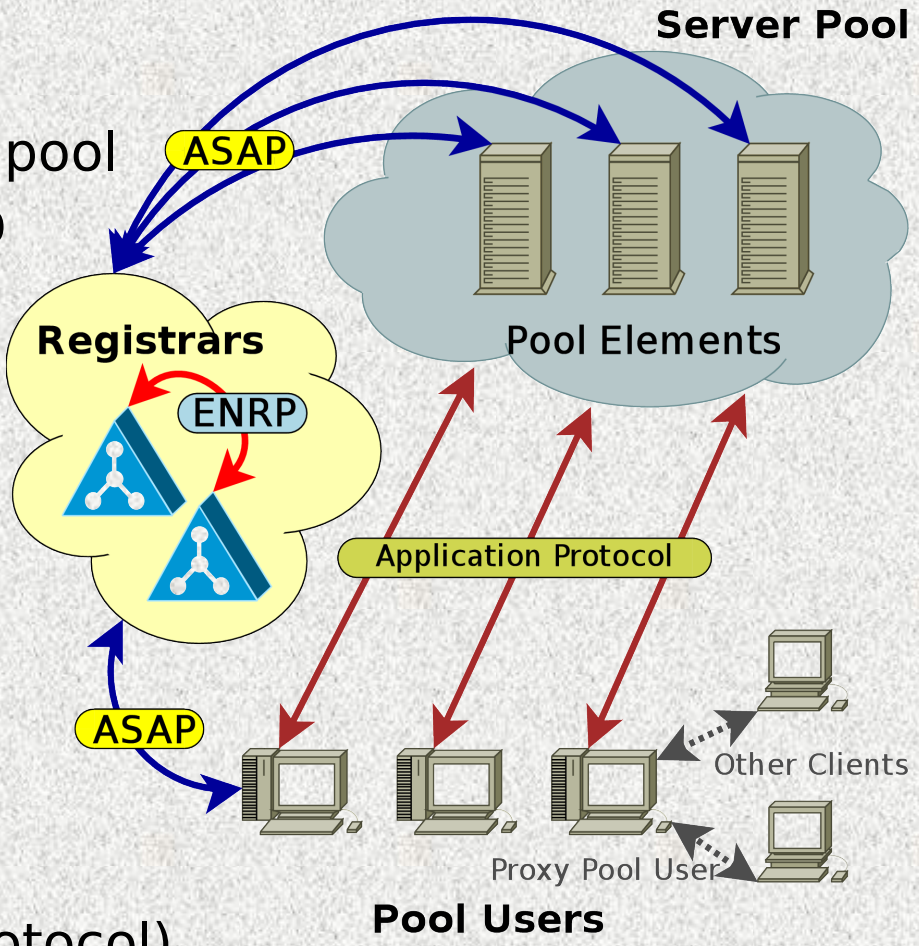
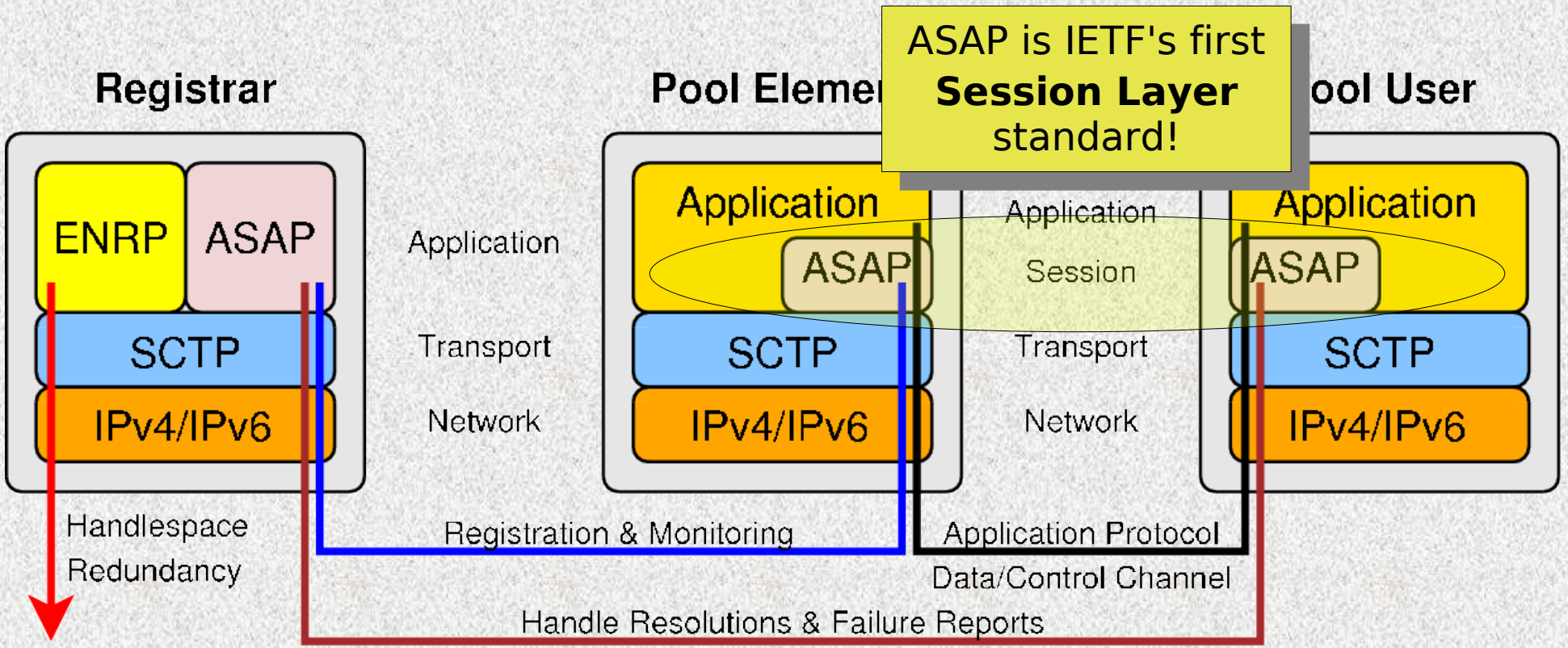
- Terminology:
  - **Pool Element (PE)**: Server
  - Pool: Set of PEs
  - PE ID: ID of a PE in a pool
  - Pool Handle: Unique pool ID
  - Handlespace: Set of pools
  - Pool **Registrar (PR)**
  - **Pool User (PU)**: Client
  - Support for Existing Applications
    - Proxy Pool User (PPU)
    - Proxy Pool Element (PPE)



- Protocols:
  - **ASAP** (Aggregate Server Access Protocol)
  - **ENRP** (Endpoint Handlespace Redundancy Protocol)

The RSerPool Protocol Stack



- Aggregate Server Access Protocol (ASAP)
  - PR ⇔ PE: Registration, Deregistration and Monitoring by Home-PR (PR-H)
  - PR ⇔ PU: Server Selection, Failure Reports
- Endpoint Handlespace Redundancy Protocol (ENRP)
  - PR ⇔ PR: Handlespace Synchronisation

The Handlespace and its Contents

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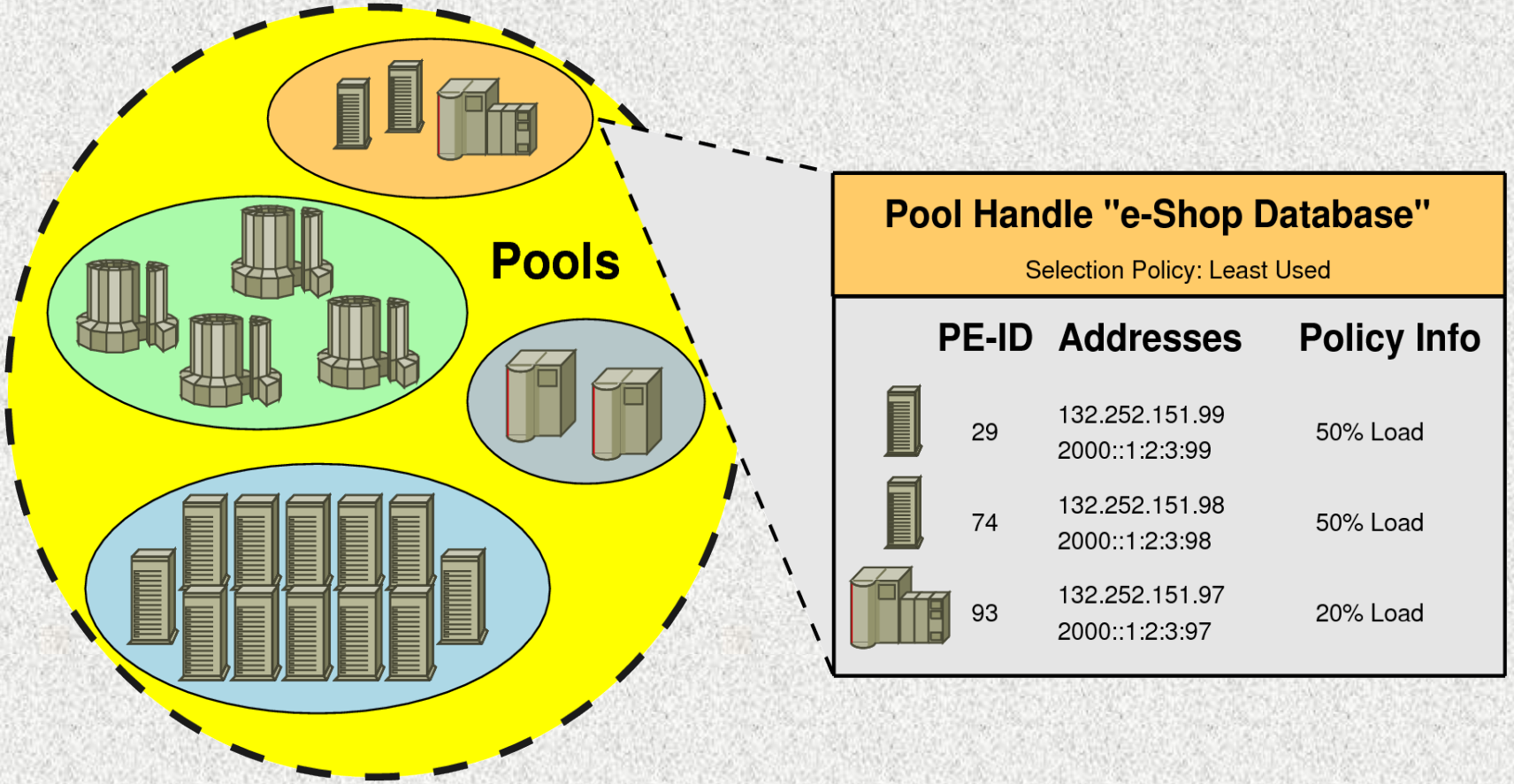
- Handlespace = set of non-empty pools
- “flat”, i.e. no hierarchy for PHs
  - very efficiently realizable (see [FGCN2007-HsMgt][Contel2005])



Automatic Configuration by Registrar Announces

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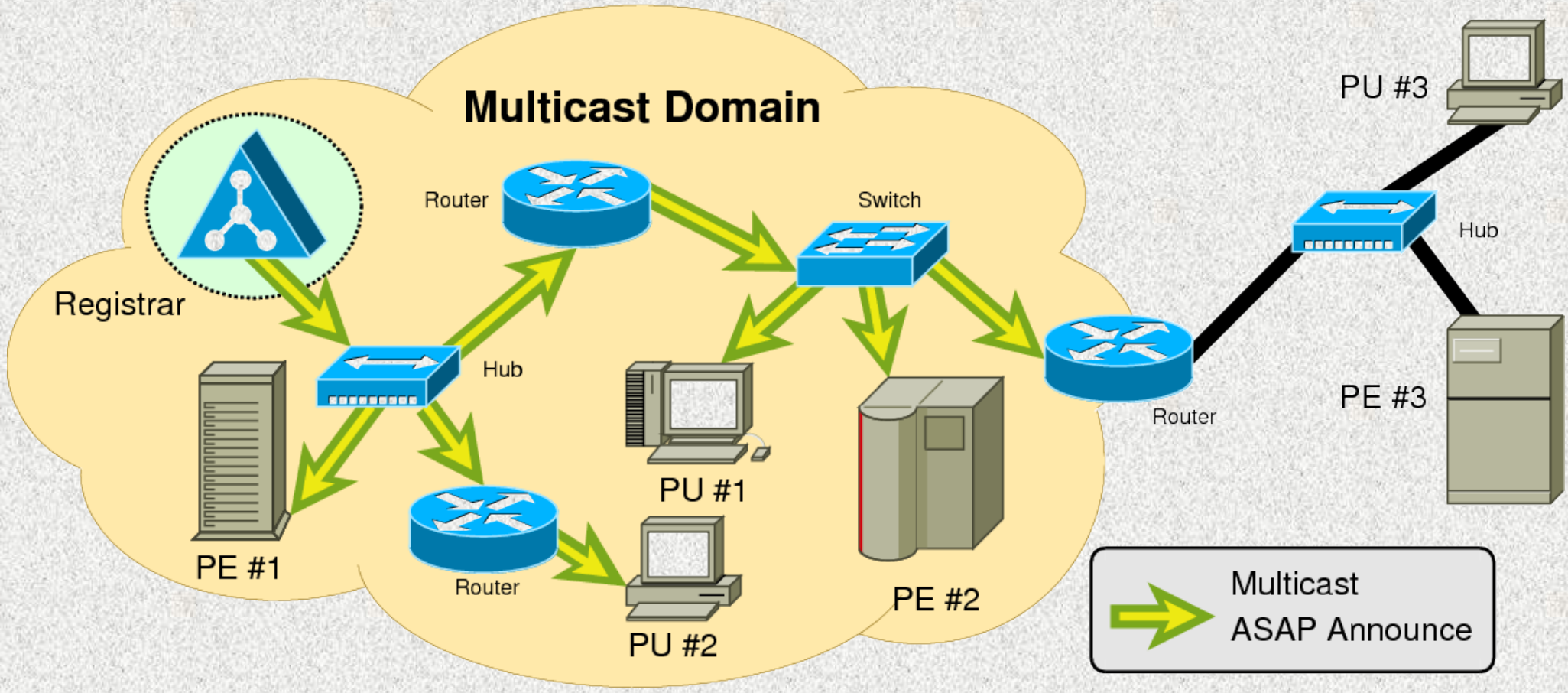
- Transport of the announces
  as UDP packets via IP multicast



Session Failover using Client-Based State Sharing

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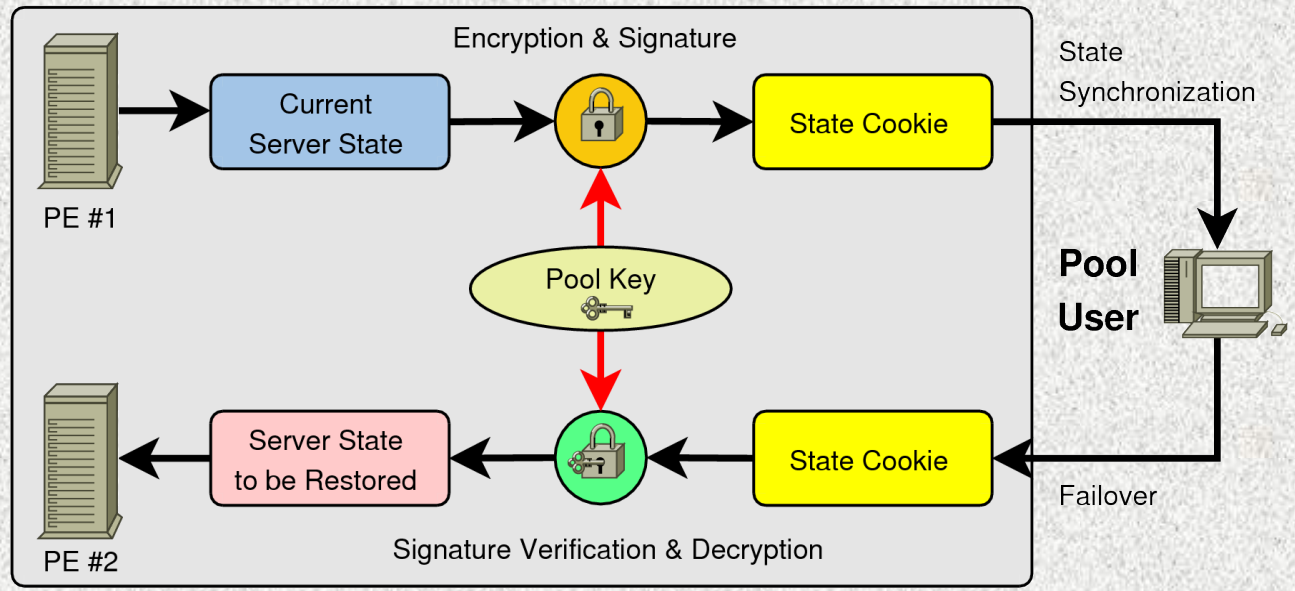
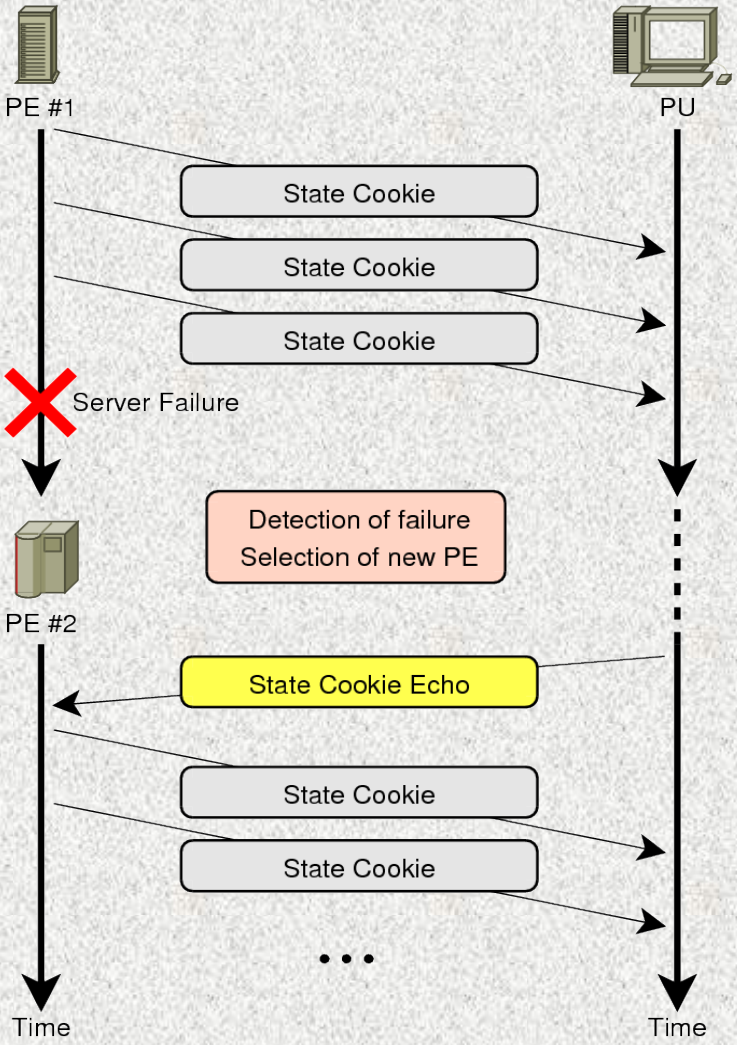
- Necessary to handle failover:
  A new PE must be able to recover the session state of the old PE
- Simple solution for many applications:
  Usage of „state cookies“ [LCN2002]
  Now part of the ASAP protocol!





RSerPool Application Scenario: Real-Time Distributed Computing

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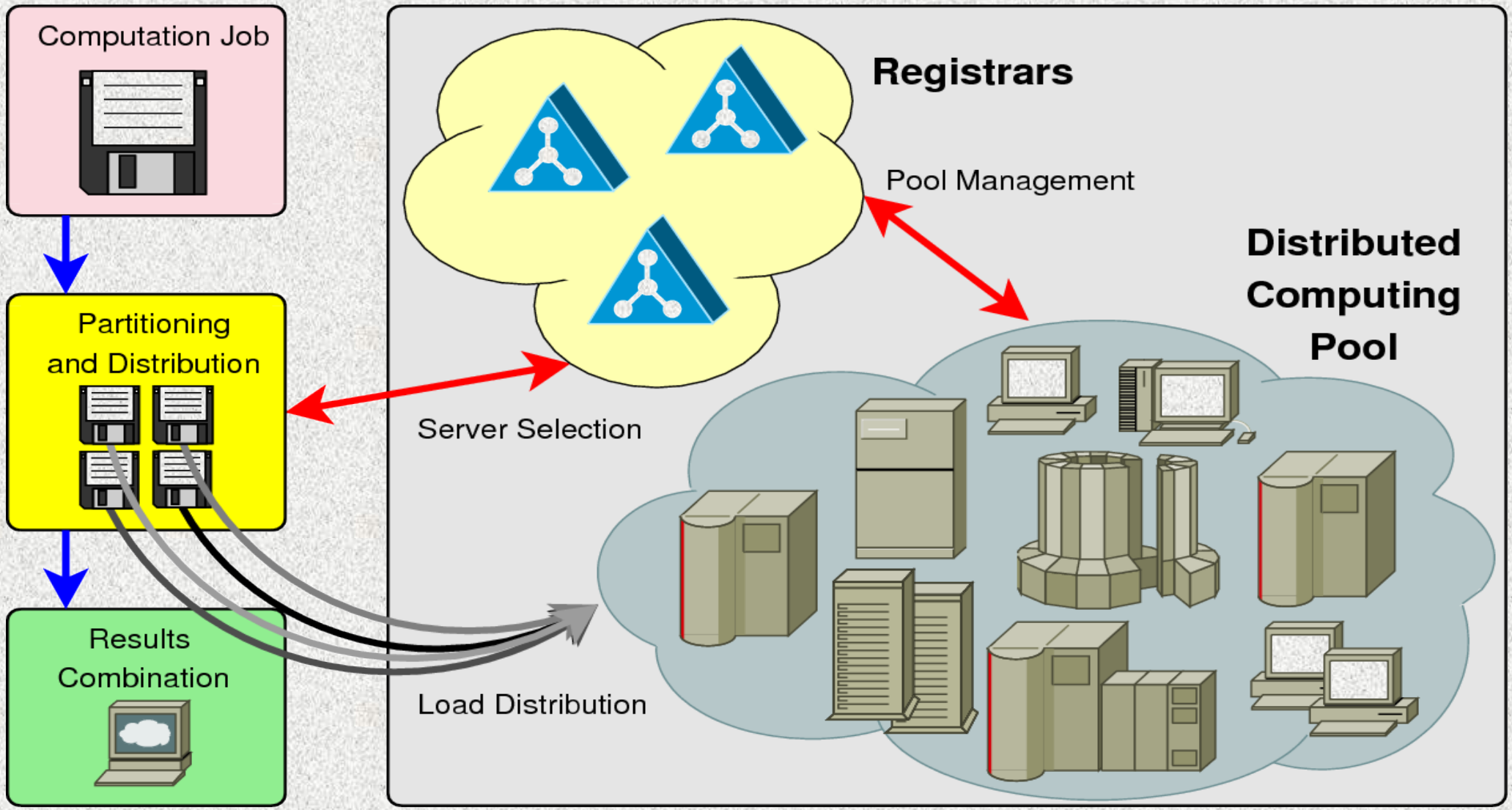

Described in [draft-dreibholz-rserpool-distcomp-03.txt]

The *RSPLIB* Implementation

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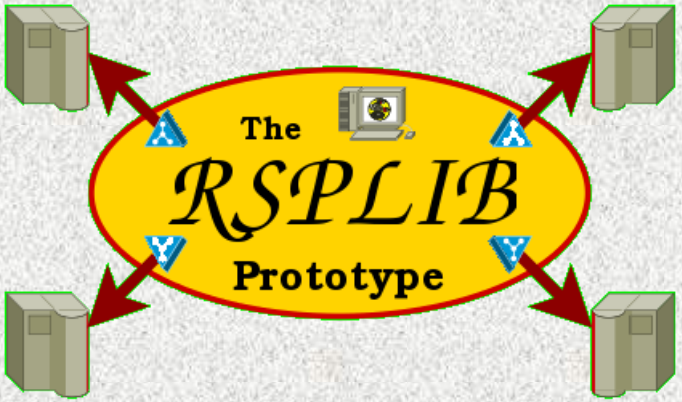
- Design decisions:
  - Open Source, GPLv3 license
  - Platform independence
    - Systems: Linux, FreeBSD, MacOS X, Solaris
    - CPUs: x86, x86_64, PPC, MIPS
  - Implemented in ANSI-C
- Basic components:
  - *RSPLIB* library for PUs and PEs
    - ASAP protocol (PU/PE side)
  - Registrar
    - ASAP protocol (PR side)
    - ENRP protocol
  - Demo system and many examples



Developed in cooperation with Siemens AG, Munich
Supported by BMBF and DFG

Thomas Dreibholz's Reliable Server Pooling Page
http://tdrwww.iem.uni-due.de/dreibholz/rserpool/

Installation

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- Download of the source archive:
  - http://tdrwww.iem.uni-due.de/dreibholz/rserpool/
- Dependencies:
  - *lksctp* package (Library for access to kernel SCTP features)
    (Alternative: our own userland SCTP implementation *sctplib/socketapi*)
  - *Qt3* developer files package (for fractal graphics demo, optional)
  - *BZip2* developer files package (for CalcApp test application)
  - C++ compiler (for the example applications)
  - Debian/Ubuntu:
    ```
    sudo apt-get install libsctp-dev libbz2-dev libqt3-mt-dev g++
    ```
- Compiling the sources:
  - `tar xzf rsplib-<Version>.tar.gz`
  - `cd rsplib-<Version>`
  - `export QTDIR=/usr/share/qt3` (Debian/Ubuntu, may be different for others)
  - `./configure --enable-kernel-sctp --enable-qt`
  - `make`
  - `sudo modprobe sctp` (if necessary: load kernel module for SCTP)

A Small Test Setup

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- Start of the PR:
  - `registrar`
  - For loopback usage (i.e. on computer without network connection):
    - Host requires at least a private-scoped IP address (e.g. 192.168.x.y)
    - Interface must have set the „multicast“ flag
    - `sudo ifconfig dummy0 192.168.100.200 netmask 255.255.255.0 up multicast`
- Start of the fractal graphics PE:
  - `server -fractal`
- Start of the fractal graphics PU:
  - `fractalpooluser`

Further information can be found in the
RSPLIB Handbook
on our project website
http://tdrwww.iem.uni-due.de/dreibholz/rserpool/

The Building Blocks of the Registrar

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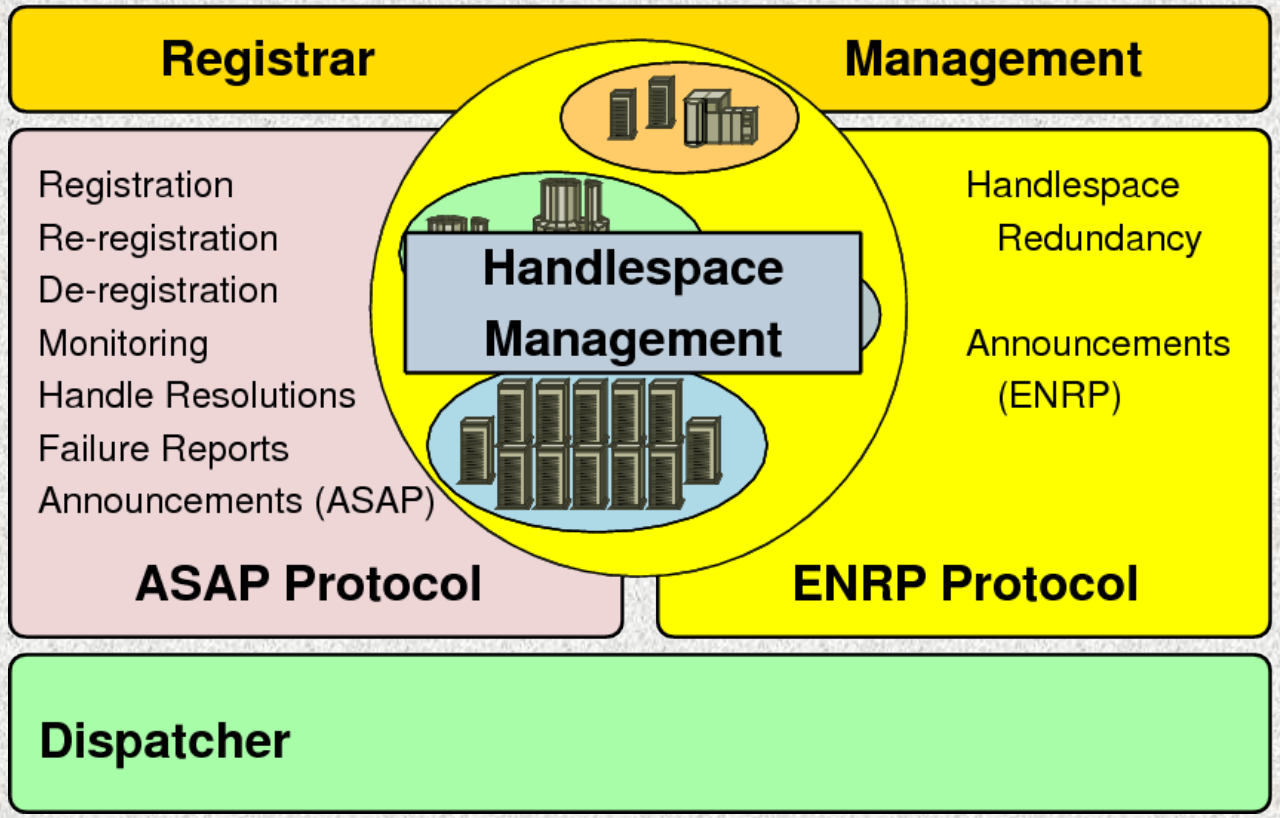
- Dispatcher:
  - Platform-specific functionalities:
    - Timers
    - Sockets
    - Threads
- Protocols:
  - ASAP
    - PR↔PE
    - PR↔PU
  - ENRP (PR↔PR)
- Registrar Mgt.:
  - Access control
  - Address verification and -filtering



- Handlespace Management (see [FGCN2007-HsMgt][Contel2005])

The Building Blocks of the *RSPLIB* Library

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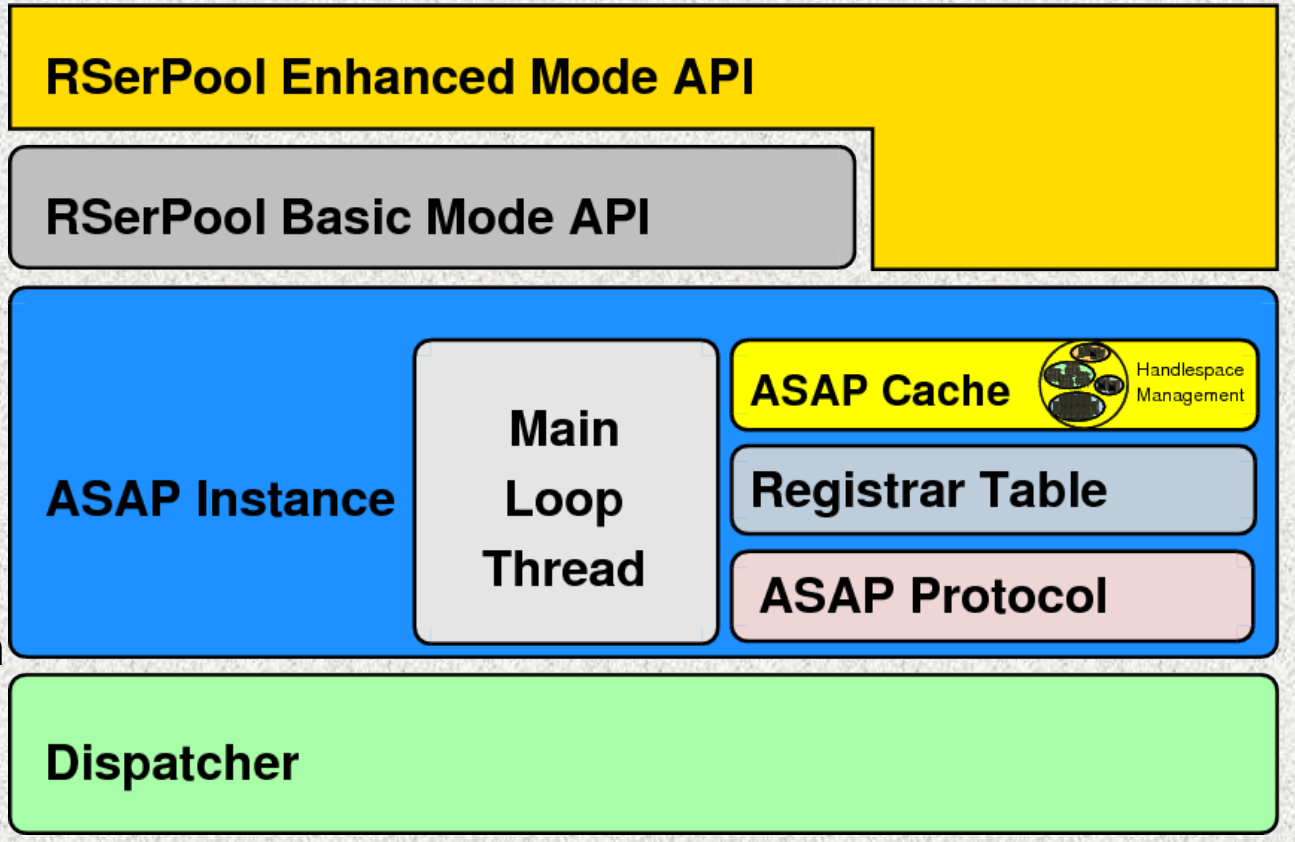
- Dispatcher

- ASAP Instance:
  - ASAP protocol
    - PE↔PR
    - PU↔PR
    - PU↔PE
  - ASAP thread
    - Request pipelining
  - List of PRs
    - from announces
    - static configuration
  - Cache for PE selection



- RSerPool APIs:
  - Basic Mode
  - Enhanced Mode

The Two RSerPool APIs

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- Basic Mode API
  - Only core functionalities (registration, deregistration, handle resolution)
  - PU $\leftrightarrow$ PE-communication **realized by** the **application itself**!
- Enhanced Mode API
  - Complete **session layer**
  - For PEs:
    - Registration management
    - Management of incoming sessions
    - Client-based state sharing
  - For PUs:

    Sessions with pools, including:
    - Selection of PEs
    - Establishment, monitoring and **management** of a **transport connection**
    - **Failover** support
    - Cookie storage and failover using client-based state sharing

The API of the *RSPLIB* Library: Enhanced Mode for PUs

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- API similar to TCP sockets client:
  - For TCP sockets: *socket*() -> *connect*() -> ... -> *close*()
  - Now: Session (RSerPool socket) instead of a simple transport connection!

```
/* Create session */
session = rsp_socket(0, SOCK_STREAM, IPPROTO_SCTP);
rsp_connect(session, "MyPool", ...);

/* Run application: file download */
rsp_send(session, "GET Linux-CD.iso HTTP/1.0\r\n\r\n");
while((length = rsp_recv(session, buffer, ...)) > 0) {
   doSomething(buffer, length, ...);
}

/* Close session */
rsp_close(session);
```

- Note:

  doSomething() may contain repetitions – depending on the cookie interval!

The API of the *RSPLIB* Library: Enhanced Mode for PEs

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- API similar to TCP sockets server:
  - For TCP sockets: *socket*() -> *bind*() -> *listen*() -> *accept*()
  - Again: Session (RSerPool socket) instead of transport connection!

```
void serviceThread(session)
{
  rsp_recv(session, command, ...);
  if(command is a cookie) {
    /* Got a cookie -> restore session state */
    Restore state;
    rsp_recv(session, command, ...);
  }
  do {
    /* Handle commands from pool user */
    Handle command;
    rsp_send_cookie(session, current state);
    rsp_recv(session, command, ...);
  } while(session is active);
  rsp_close(session);
}


int main(...)
{
```

```
  /* Create and register pool element */
  poolElement = rsp_socket(0,SOCK_STREAM,IPPROTO_SCTP);
  rsp_register(poolElement, "MyPool", ...);

  /* Handle incoming session requests */
  while(server is active) {
    /* Wait for events */
    rsp_poll(poolElement, ...);

    if(incoming session) {
      /* Accept new session */
      session = rsp_accept(poolElement, ...);
      Create service thread to handle session;
    }
  }

  /* Deregister pool element */
  rsp_deregister(poolElement);
  rsp_close(poolElement);
}
```

The Scripting Service: Using RSerPool in Shell Scripts

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- Another example application: **Scripting Service**
  - **Scripting PE**:
    - Gets Tar/GZip file from PU
    - Archive is extracted, a contained script is executed
    - Results will be Tar/GZip-archived and sent back to PU
  - **Scripting PU**:
    - Get (from user) a Tar/GZip archive with script (and input files)
    - Distributes archive to scripting PE in pool
    - Receives back the results

- Application example:
  - **Distribution** of **simulation runs**
  - Realized with only about 50 lines of *bash* shell code.

- Current work on the scripting service (as student projects):
  - Security! Idea: usage of **virtualization** (e.g. Xen)
  - Failover handling: application **checkpointing**

Our RSerPool Activities

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- Research as part of a DFG-funded project since October 2004
  - Simulation model *RSPSIM*
  - Prototype implementation *RSPLIB*

Interested in our RSerPool research papers and presentations? Have a look at our website!

from simulation to reality

from research to application

- Standardization in the IETF
  - Contribution of 4 **Working-Group-Drafts** ...
    - draft-ietf-rserpool-overview-02.txt
    - draft-ietf-rserpool-policies-07.txt
    - draft-ietf-rserpool-mib-04.txt
    - draft-ietf-rserpool-api-00.txt
  - ... and multiple **Individual Submissions**
  - IETF standardization relies on „running code“ - we have it!
  - *RSPLIB* is the world's first complete RSerPool implementation
    - **Open Source** (GPLv3 license)
    - **Reference implementation** of the IETF RSerPool WG

Thank You for Your Attention!
Any Questions?

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Technik der Rechnernetze

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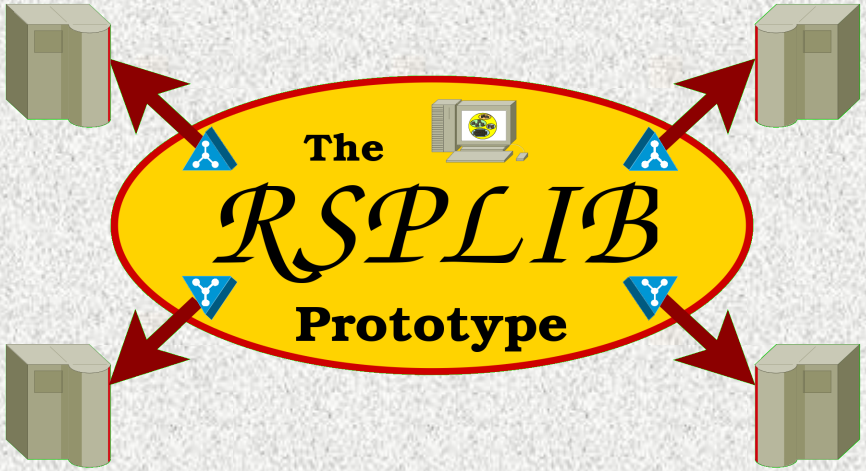
IETF

Deutsche Forschungsgemeinschaft DFG

IEEE



Fachhochschule Münster University of Applied Sciences

To be continued ...

Visit Our Project Homepage:

http://tdrwww.iem.uni-due.de/dreibholz/rserpool/

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