Policy Management
in the
Reliable Server Pooling Architecture

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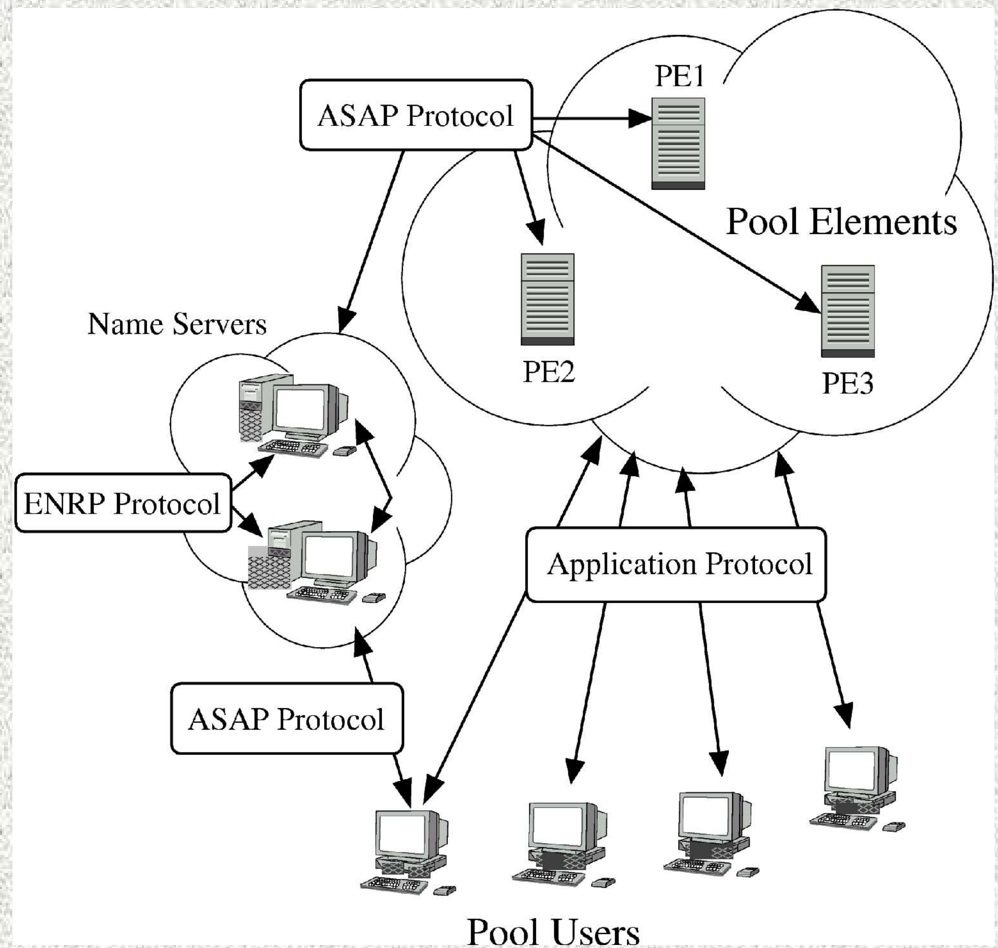
What is Reliable Server Pooling (RSerPool)?

- Some applications require high availability, e.g.
  - e-Commerce
  - Medicine
  - ...
- No single point of failure => multiple redundant servers for same service (server pool) => **RSerPool** – A unified solution for server pool management
- Based on SCTP (Stream Control Transmission Protocol)
- Under Standardization by IETF RSerPool WG
- Important RSerPool task: Selection of servers ...
  - Load Balancing, application-specific policies
- RSerPool architecture also usable for new applications:
  - Mobility Management
  - Distributed Computing

What is Reliable Server Pooling (RSerPool)?

- Terminology:
  - Pool Element (PE): Server
  - Pool
  - PE ID: Unique ID of PE
  - Pool Handle: Unique ID of pool
  - Namespace
  - Name Server (NS)
  - Pool User (PU): Client



- Protocols:

  ASAP (Aggregate Server Access Protocol)

  ENRP (Endpoint Name Resolution Protocol)

Server Selection and Pool Policies

- How does a PU access a pool's service
  - PU asks an arbitrary NS to select *appropriate* PEs of a certain pool
  - PU may add them to its cache (optional) and selects one *appropriate* PE
  - PU connects to selected PE
- How is a PE selected *appropriately*?
  - Pool Policies:
    - Weighted Round Robin (defined in RSerPool Internet Draft)
    - Least Used (defined in RSerPool Internet Draft)
    - Weighted Random (will be defined in RSerPool Internet Draft)
    - and many more; possibly service-specific extensions ...
- **Many PEs** in pools of **many different policies ...**

  How can a namespace be **managed efficiently**?

  (Internet Drafts only define policy behaviour, but not implementation ...)

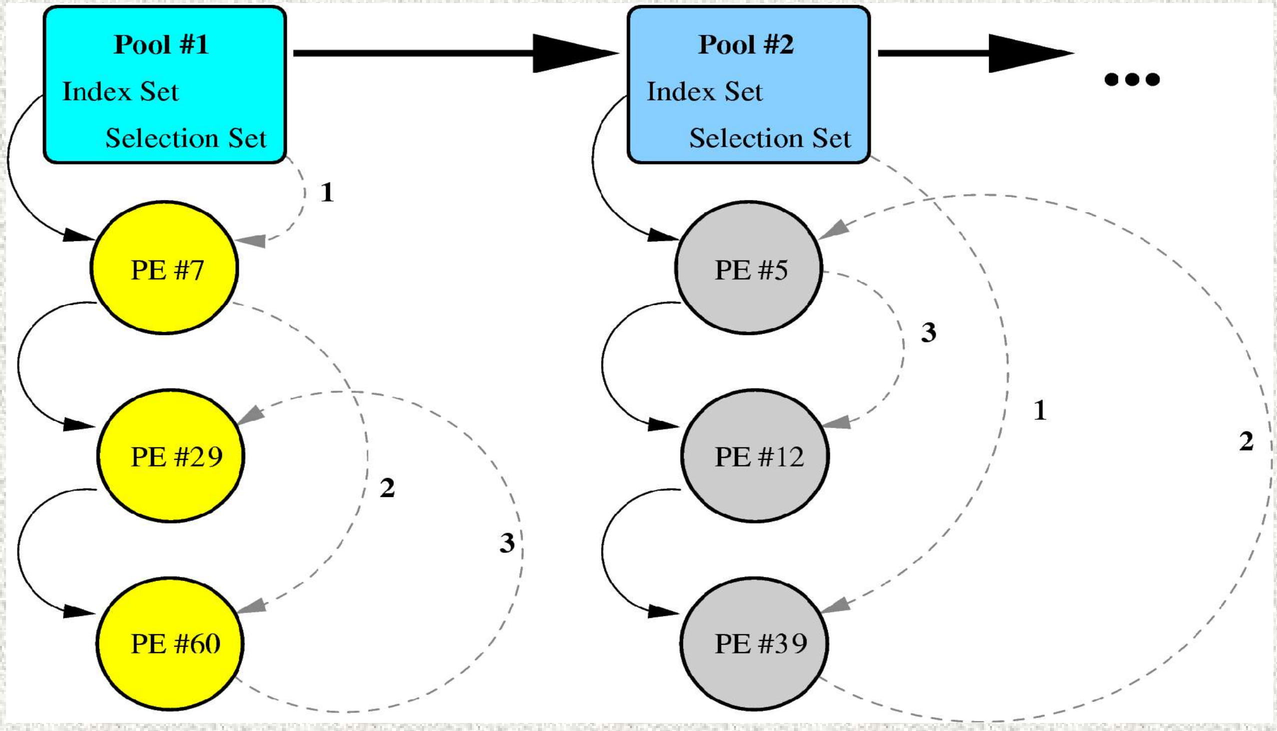
Namespace Management - What are the requirements?

- For Pool Elements:
  – (Re-)Registration, i.e. lookup (by PE ID) + insertion of PE entry
  – Deregistration, i.e. removal of PE entry
- For Pool Users:
  – Resolution of Pool Handle to set of PE entries, appropriately selected by the pool's policy
- For Name Servers:
  – Step-wise traversal of Namespace, e.g. get first 100 PE entries, continue with next 100, and so on ...

- Main Observations:
  1. for PEs: pool **access** by **pool element ID**
  2. for PUs: pool **access** by **selection order** (depending on pool policy)

Our Namespace Management Concept

- **Namespace:**
  - **Pool Set**, sorted by **pool handle**
- **Pool:**
  - **PE Index Set**
    - sorted by: **PE ID**
  - **PE Selection Set**
    - sorted by: **Sorting Order**
  - **Selection Procedure**



- Quite straightforward, but ...

  How can certain policies (Least Used, Weighted Round Robin) be expressed as „Sorting Order“ and „Selection Procedure“?

Defining „Sorting Order“

- Part 1: Policy-Specific Sorting Key
  - Policy-dependent sorting key, e.g. *load* for Least Used
- Part 2: Sequence Number
  - For every pool: pool-wide global sequence number
  - For every PE entry: PE sequence number
  - **New PE entry** or **PE entry selected**:
    - PE's sequence number := pool's sequence number
    - **Increment** pool's sequence number
  - Note: A PE entry's sequence number is **unique** within its pool!
- **Sorting Order** := Sorting by **composite key** (Pol.-Spec. Key, PE Seq.No.)
- Usual **Selection Procedure** :=
  - Simply take first PE entry from the Selection Set
  - **Update** its sequence number + possibly its pol.-spec. key; **re-insert** it

Our Policy Realizations

- IETF drafts define what policies mean, but not how to implement them!
- Least Used:
  - **Sorting Order:** Sorting by (PE load, Seq.No.)
  - **Selection Procedure:** Take first PE of the Selection Set
  - Note: Seq.No. ensures round robin selection between equal-loaded PEs
- Weighted Round Robin
  - For each PE: Round Counter *r*, Virtual Counter *v* (Selections to go for current round)
  - **Sorting Order:** Sorting by (*r*, *v* (descending), Seq.No.)
  - **Selection Procedure:** Take first PE of the Selection Set
- Weighted Random:
  - For each PE: weight specifies proportional selection probability
  - For each pool: WeightSum := Sum of all PEs' weights
  - **Sorting Order:** PE ID only (ensures unique order)
  - **Selection Procedure:** Random number $r \in \{0, \ldots, \mathrm{WeightSum}\} \subset \mathbb{R}$ exactly maps to one PE

Example 1: Least Used Policy

- Sorting Order: Sorting by (PE load, Seq.No.)
- Selection Procedure: Simply take the **first** PE of the Selection Set
- **Before Selection:**

Pool „Example“	Policy LU seq=8	PE #7	load=10%	seq=6
		PE #2	load=10%	seq=7
		PE #11	load=44%	seq=3

PE #7 will be selected next (lowest load and lowest seq.no. for this load)

- **After Selection:**

Pool „Example“	Policy LU seq=9	PE #2	load=10%	seq=7
		PE #7	load=10%	seq=8
		PE #11	load=44%	seq=3

  – PE #2 will be next one, then again PE #7 and so on ...
  – Seq-No. ensures round-robin selection between PEs of equal load!

Example 2: Weighted Round Robin

- For each PE entry:

  Round Counter *r*, Virtual Counter *v* (Selections to go for current round)
- Sorting Order: Sorting by (Rd.Cntr, Vrt.Cntr. descending, Seq.No.)
- Selection Procedure: Take first PE
- Example:

Pool „Example“	Policy WRR seq=9	PE #5	weight=2	r=20	v=2	seq=6
		PE #1	weight=1	r=20	v=1	seq=7
		PE #9	weight=1	r=20	v=1	seq=8

Pool „Example“	Policy WRR seq=10	PE #1	weight=1	r=20	v=1	seq=7
		PE #9	weight=1	r=20	v=1	seq=8
		PE #5	weight=2	r=20	v=1	seq=9

Pool „Example“	Policy WRR seq=11	PE #9	weight=1	r=20	v=1	seq=8
		PE #5	weight=2	r=20	v=1	seq=9
		PE #1	weight=1	**r=21**	v=1	seq=10

Next: PE #9, finally PE #5. End of WRR round 20.

Example 3: Weighted Random

- Sorting Order: Sorting by PE ID only (for unique identification)
- For each PE entry:
  - *value*, i.e. its selection probability
  - For each pool: Value Sum := Sum of all PEs' *value* settings
- Selection Procedure:
  - Get random number $r \in \{0, \ldots, \mathrm{ValueSum}\} \subset \mathbb{R}$
  - *r* maps to exactly one PE
- Example:

Pool „Example“	Policy WRAND seq=10 ValueSum=6	PE #17	weight=1	value=1
		PE #8	weight=3	value=3
		PE #11	weight=2	value=2

r=5.25 => [0, 1[for PE #17; [1, 4[for PE #8; [4, 6] for PE #11

=> Selection of PE #11

Implementation

- We use *sets* for Pools, Index and Selection, but ...

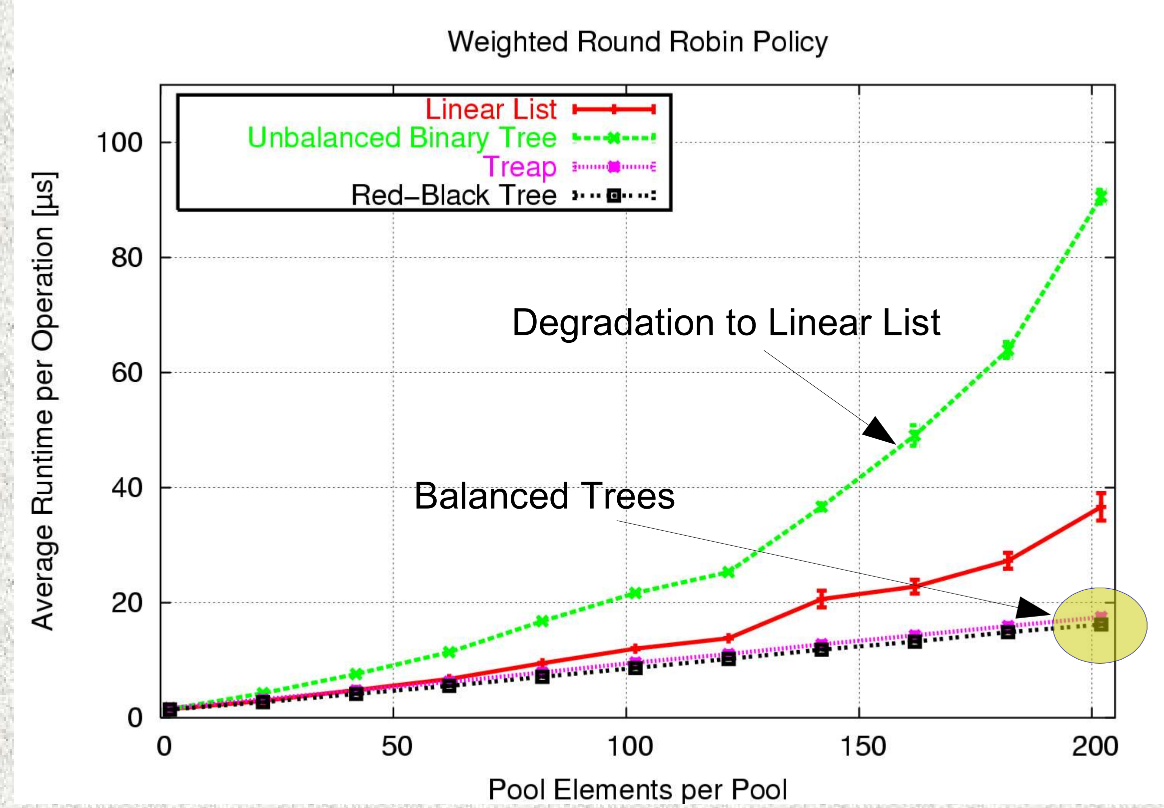
  ... How should we implement a *set*?

- Possible Data Structures:
  - Linear List
  - Unbalanced Binary Tree
  - Balanced Binary Tree (Red-Black)
  - Randomized Binary Tree (Treap)
- Question now:
  - Which is most efficient?
  - What is average namespace operation runtime on „standard PC“ hardware (AMD Athlon 1.3 GHz)?

=> Performance Evaluation!

Performance Evaluation

- Transactions Scenario
- Operations Ratio:
  - Registrations: 1
  - Reregistrations: 30
  - PE Selections: 5
  - Traversal: 10
- Avg. Operation Runtime:
  10 pools
  2 to 202 PEs per pool



- Results:
  - Avg. runtime **less than 20µs** for 10 pools of 202 PEs (balanced trees)!
  - Unbalanced trees unsuitable (insertion/removal too systematic)

Performance Evaluation (Scalability)

- Distributed Computing Scen.
- Operations Ratio:
  - Registrations: 1
  - Reregistrations: 300
  - PE Selections: 5000
  - Traversal: 1
- Avg. Operation Runtime:

  1 pool

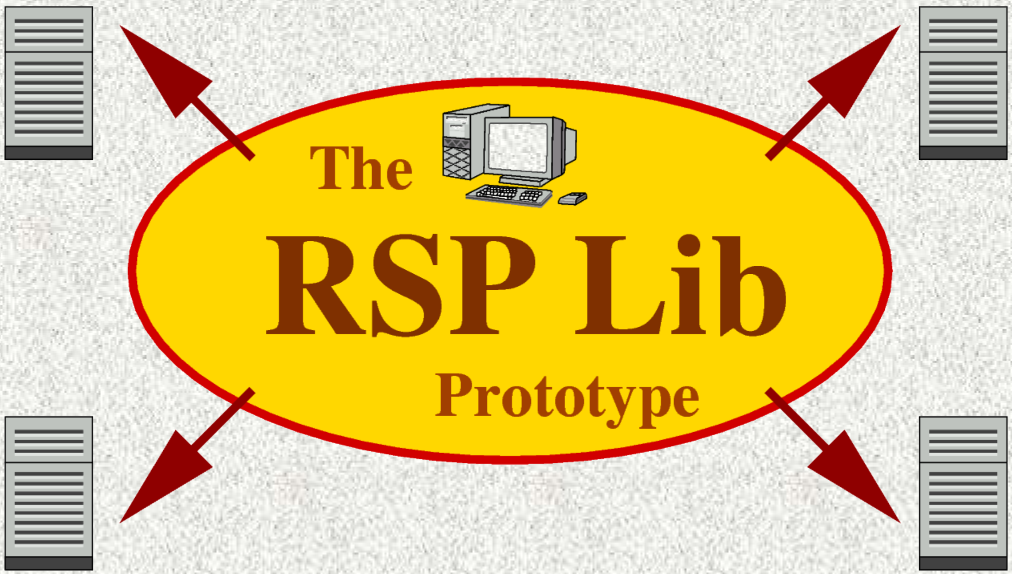
  10 to 100010 PEs

- Results:
  - Acceptable runtime even for very large pools (**< 70µs** for 100010 PEs)!

Conclusions & Outlook

- Namespace and Policy Management is basic task of RSerPool
  - Must be efficient -> Large pools (e.g. for distributed computing)
  - Must be extendable -> New policies for new applications
- Proposed Solution: Reduction of problem to ...
  - Definition of policy-specific **sorting orders** and **selection procedures**
  - Storage of **sorted sets**
  - Efficiency shown by performance evaluation => best for **balanced trees**
- Current Status
  - Implementation of Namespace and Policy Management as C Library
  - Usage for our OMNeT++ RSerPool simulation model *rspsim*
- Future Plans
  - Usage of our library also in our Open Source RSerPool Prototype *rsplib*
  - Full implementation of the RSerPool standard by 09/2004.

Any Questions?



Project Homepage:

http://tdrwww.exp-math.uni-essen.de/dreibholz/rserpool/

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