Grid-Proof Programming Models

Jason Maassen
jason@cs.vu.nl

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Before lunch ...

- We looked at how Ibis makes Grids user friendly:
  - **JavaGAT** provides an easy-to-use API for the various flavours of Grid middleware
  - **Zorilla** provides a configuration free alternative to existing Grid middleware
  - **SmartSockets** provides an easy-to-use library that solves connectivity problems

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Remaining problems

- However, grids are still:
  - **Heterogeneous**: many differences in hardware, performance, OS, libraries, etc.
  - **Faulty**: machines may be claimed by others, lose contact, or simply crash
  - **Malleable**: the set of available machines varies constantly
- Therefore we need ways to make applications **Grid Proof**

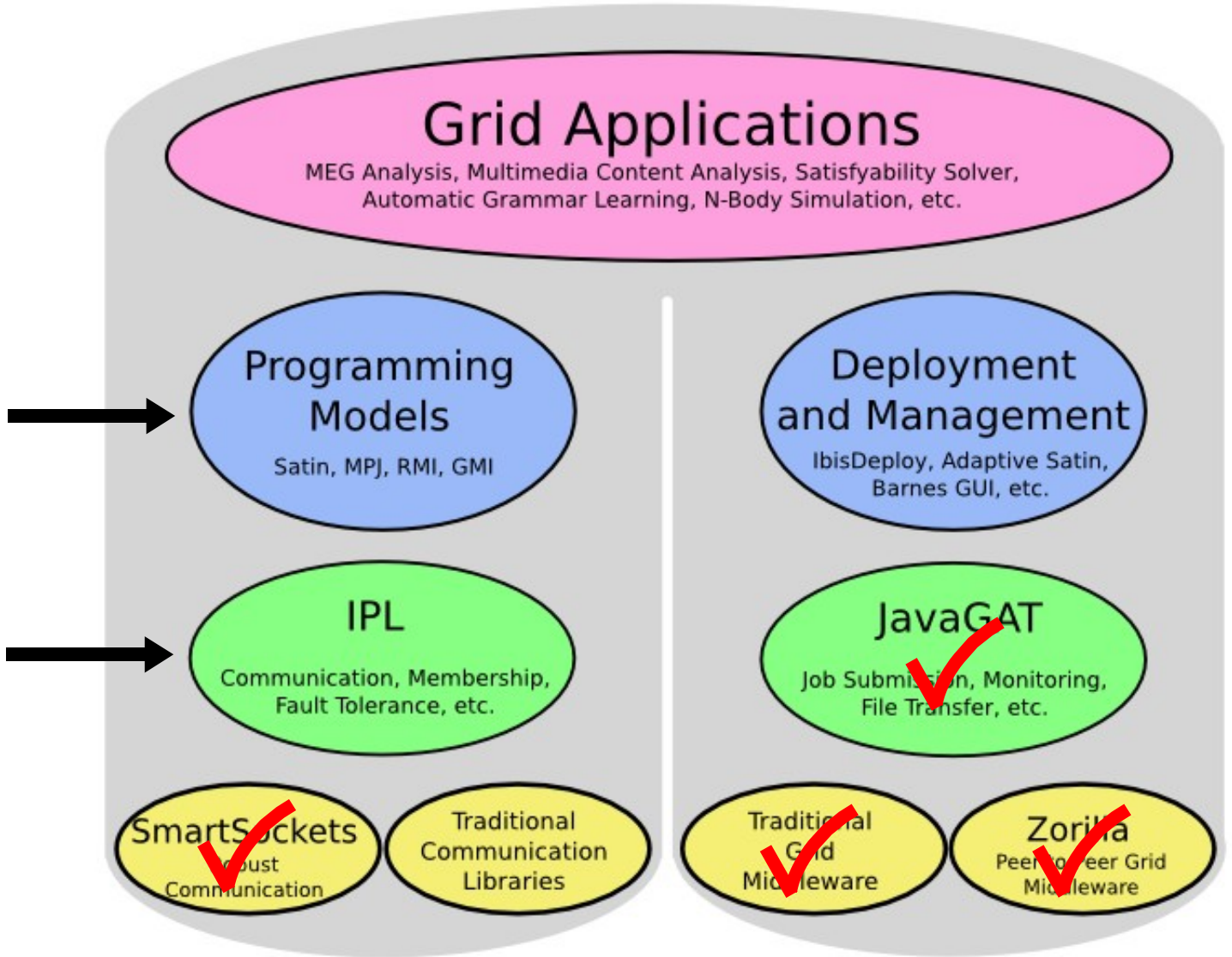
Grid Proof

- **Heterogeneity**:
  - Solved by using modern languages that run in a managed execution environment:
    - Safer and more portable
    - Easy to deploy and less dependencies
      - no compilation on grid sites
      - no libraries, headers, scripts, compilers, build tools...
  - **Java**, Python, Fortress, C#, ...
    - Language level virtualization
    - Alternative: system level virtualization

Grid Proof -- cont'd

- **Fault tolerance**:
  - We cannot prevent machines crashing
  - However, we can provide mechanisms to detects crashes ...
  - .. and use those to implement fault-tolerant programming models!
- **Malleability**:
  - Cleanly adding / removing machines
  - Handled by same mechanism

Overview



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Ibis Portability Layer (IPL)

- Simple API for Grid Communication
  - Flexible communication model
    - connection oriented messaging
    - abstract addressing scheme
  - Malleability/Fault Tolerance
    - notifications when machines join/leave
    - open & closed world (not just SMPD)
  - Serialization
    - send bytes, doubles, objects, etc.

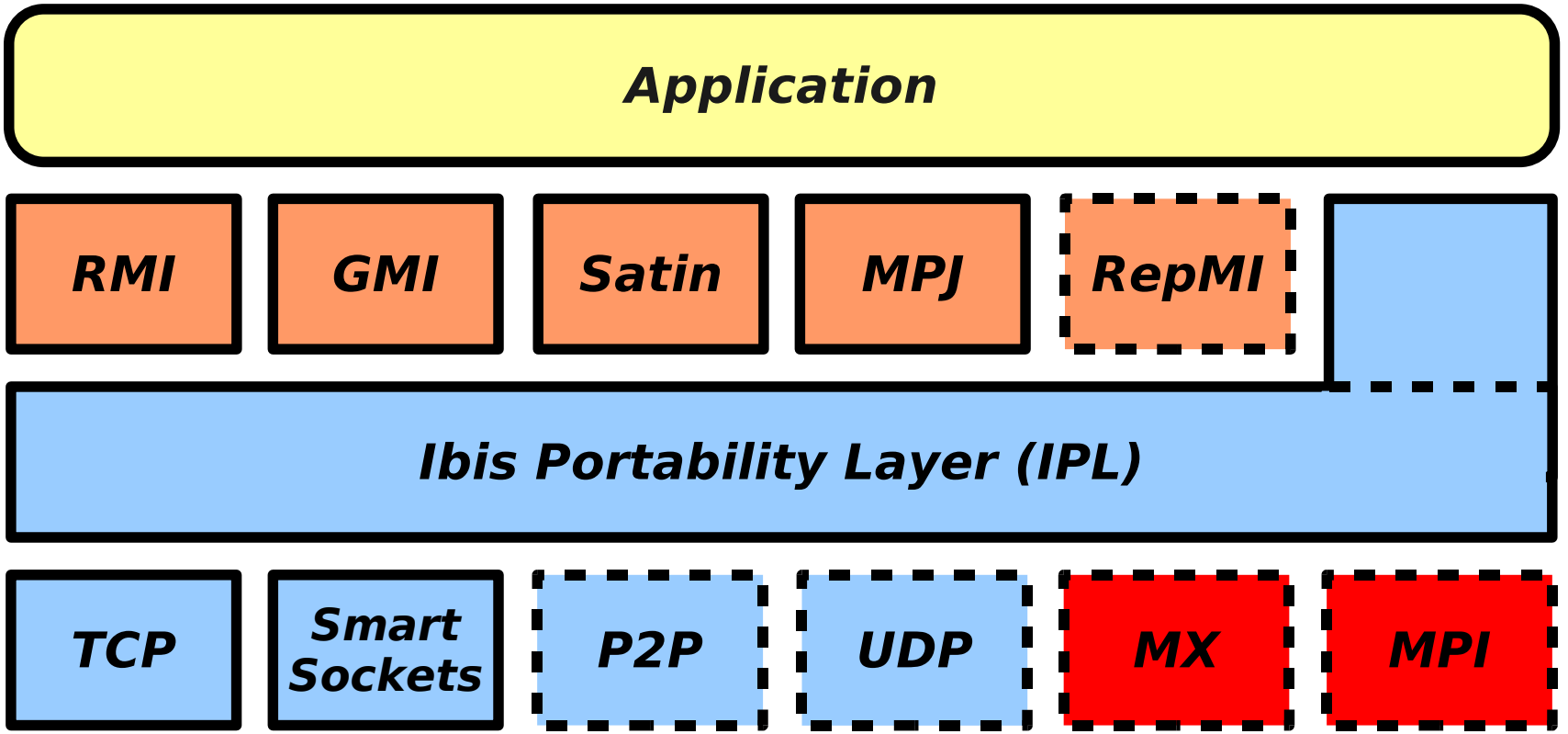
IPL

- Clean & abstract API
- Designed with Grids in mind
  - Hides network specific details
    - hostnames, IP addresses, MPI ranks, etc
    - Uses **IbisIdentifier** instead
  - Results in more portable applications
- Implemented on top of TCP, MPI, MX...

IbisIdentifiers

- IbisIdentifier:
  - Abstract 'machine address' object
  - Uniquely identifies an IPL instance
- Why don't we use ranks ?
  - Complicates malleability
    - what happens to the ranks when machines leave or crash ?
  - Ranks can be implemented using IbisIdentifiers!

IPL and Friends



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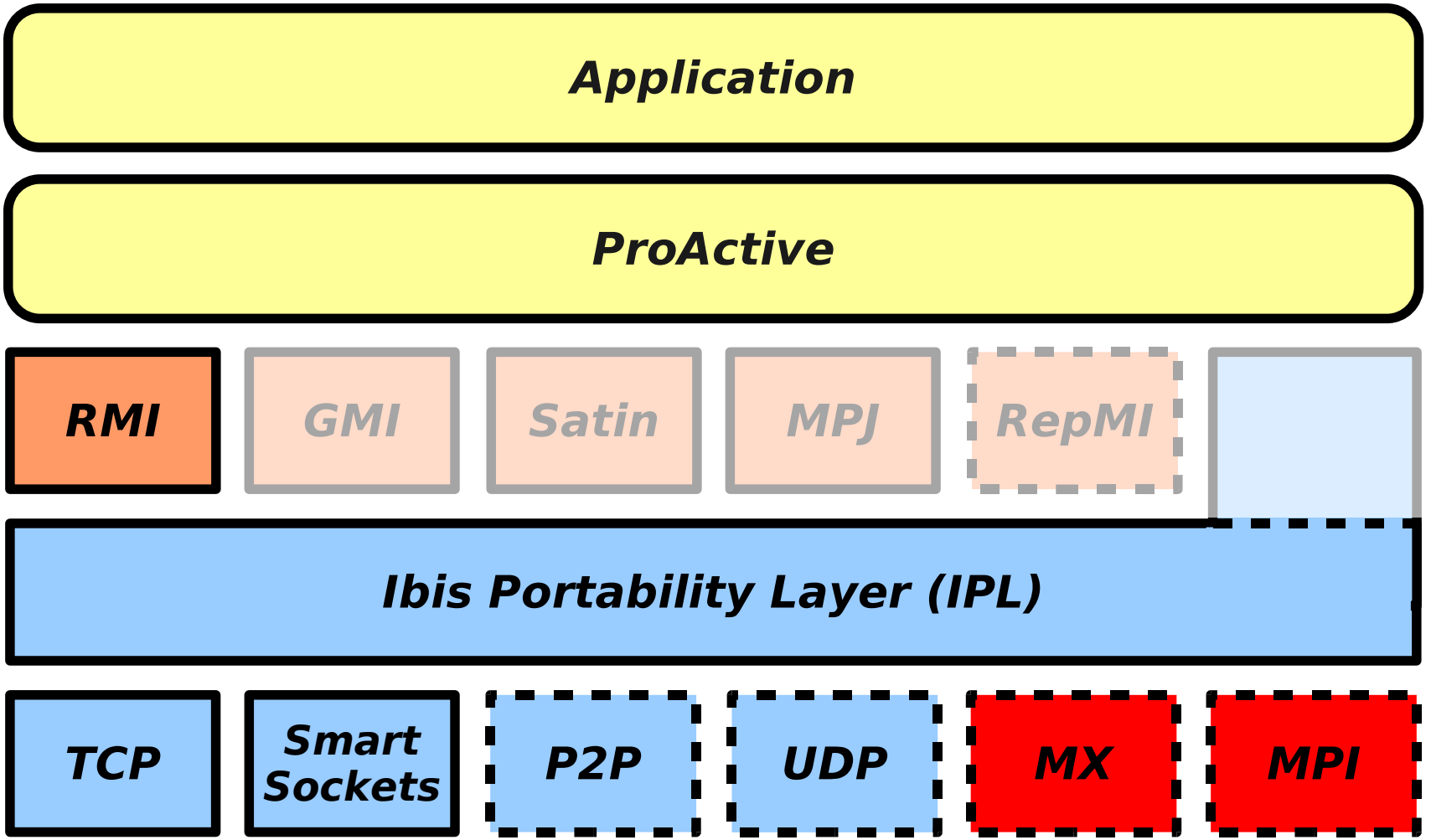
Example

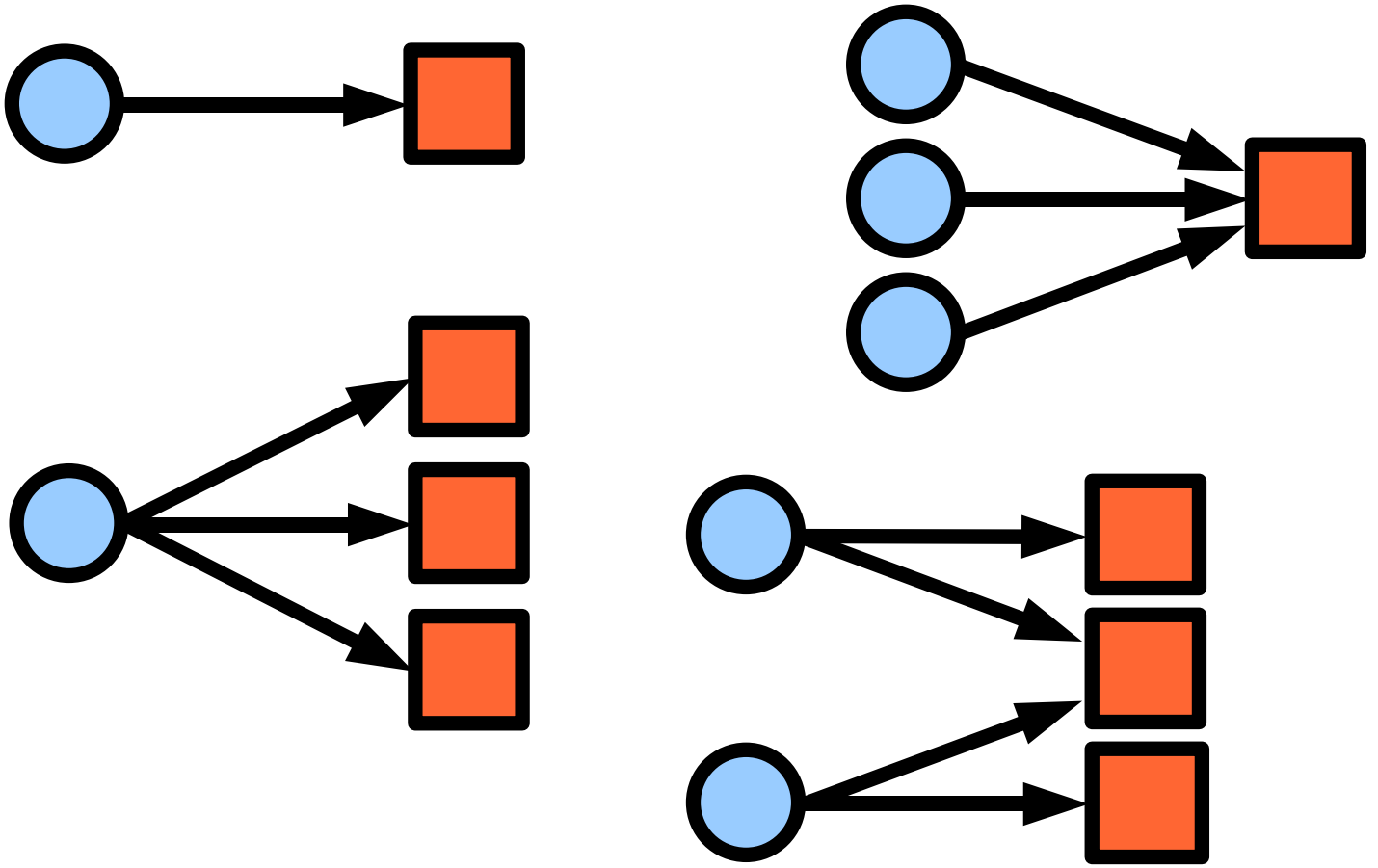


Communication

- Simple communication model
- Unidirectional pipes
- Two end points
- Connection oriented
  - allows streaming (good with high latency)

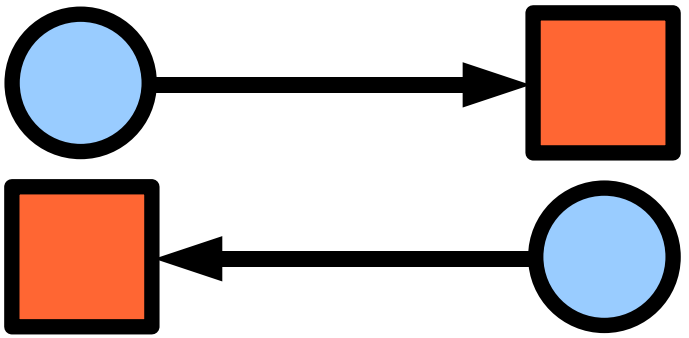
Send & receive ports

- Can be connected in arbitrary ways



Send & receive ports

- Simplicity may cause some additional administration...
  - Example: need two pairs for RPC / RMI



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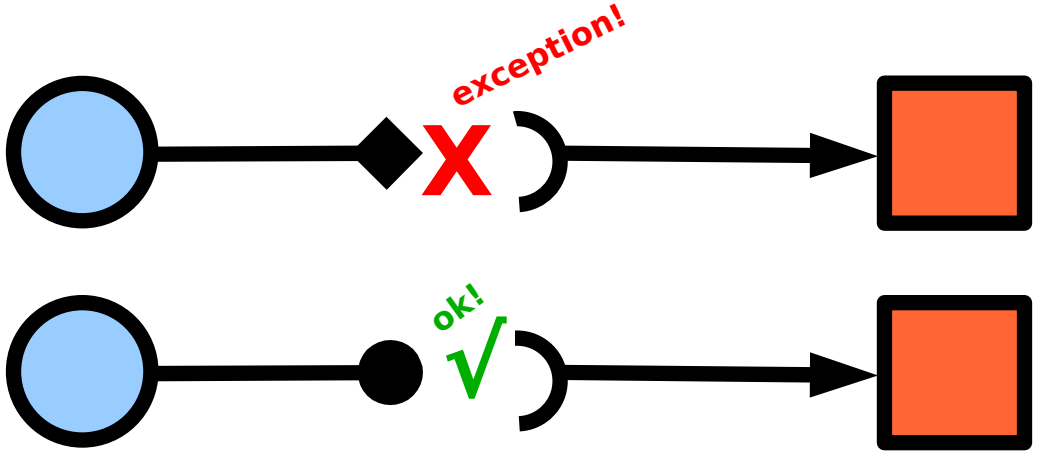
Port Types

- All ports have a **type**
  - Defined at runtime
  - Specify set of capabilities
- Types must match when connecting!



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Port Types

- Forces programmer to specify how each communication channel is used
  - Prevents bugs
    - Exception when contract is breached
  - Allows efficient implementation to be selected
    - Unicast only ?
    - Bytes only ?
    - Can save a lot complexity!

Port Types

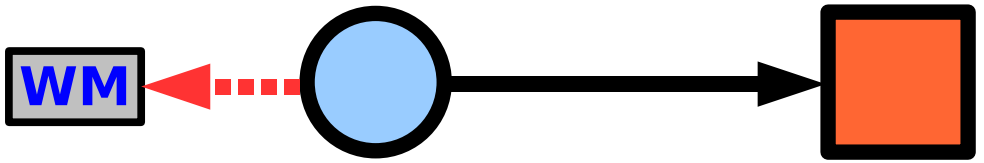
- Consists of a set of capabilities:
  - Connection patterns
    - Unicast, many-to-one, one-to-many, many-to-many.
  - Communication properties:
    - Fifo ordering, numbering, reliability.
  - Serialization properties:
    - bytes, data, object
  - Message delivery:
    - Explicit receipt, automatic upcalls, polling

Messages

- Ports communicate using 'messages'
- Contain read or write methods for
  - Primitive types (byte, int, ...)
  - Object
  - Arrays slices (partial write / read in place)
- Unlimited message size

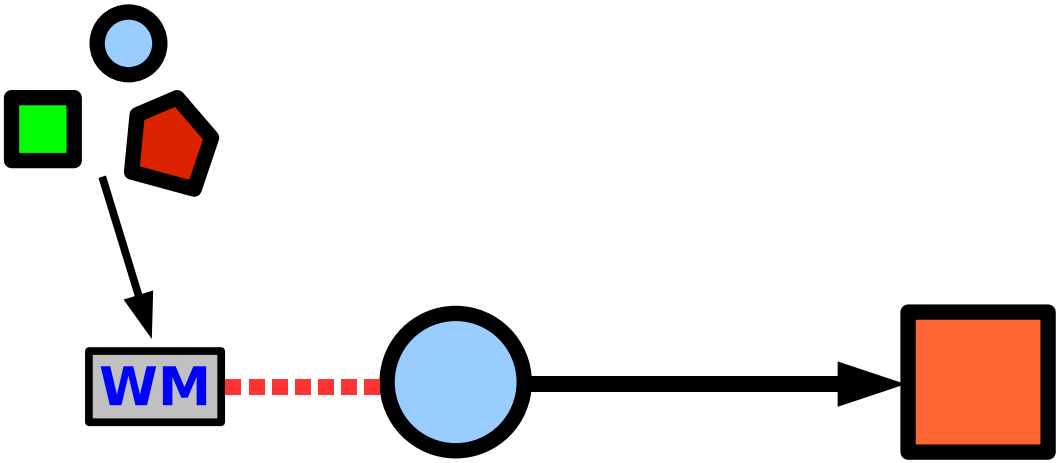
Messages

- Get WriteMessage from SendPort



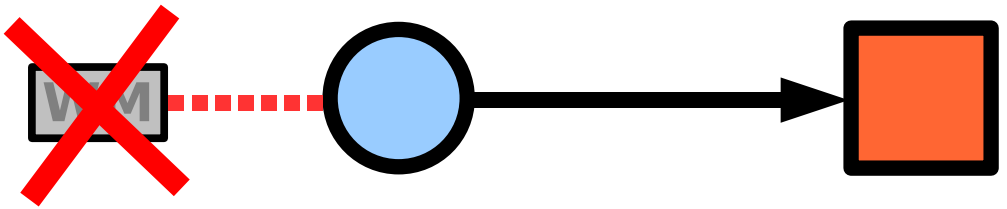
Messages

- Write data into WriteMessage



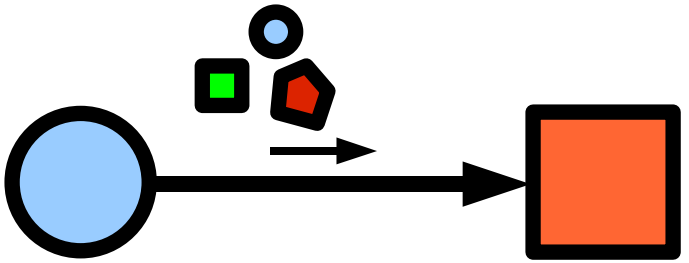
Messages

- Finish the WriteMessage



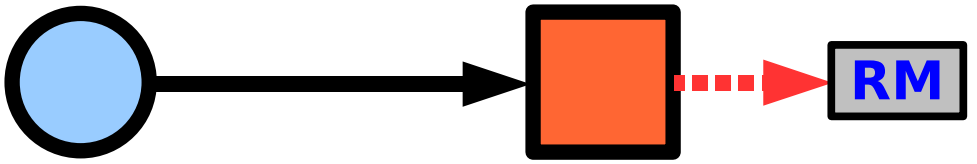
Messages

- Data is send to ReceivePort



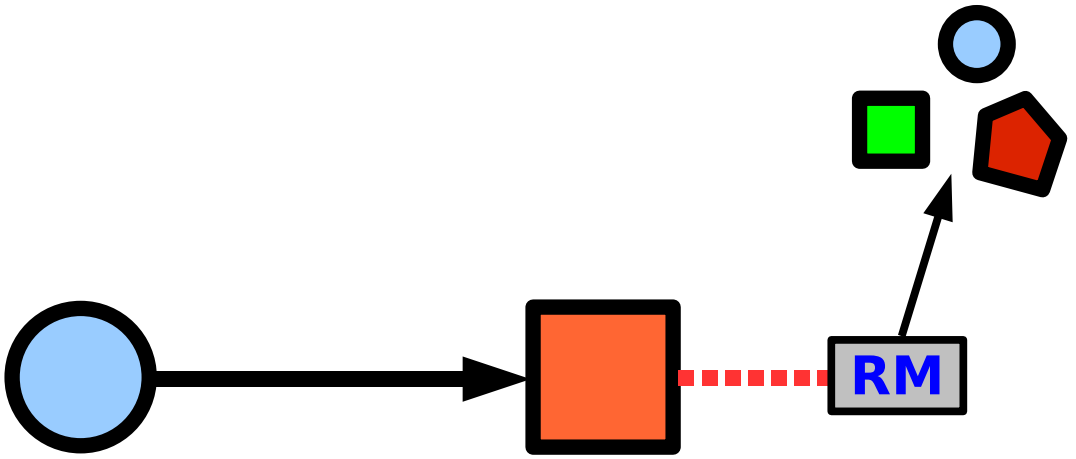
Messages

- ReceivePort produces ReadMessage
  - Explicit receive or callback (upcall)



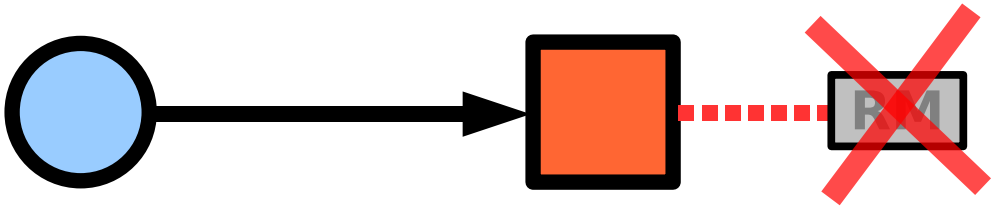
Messages

- Read data from ReadMessage



Messages

- Finish the ReadMessage

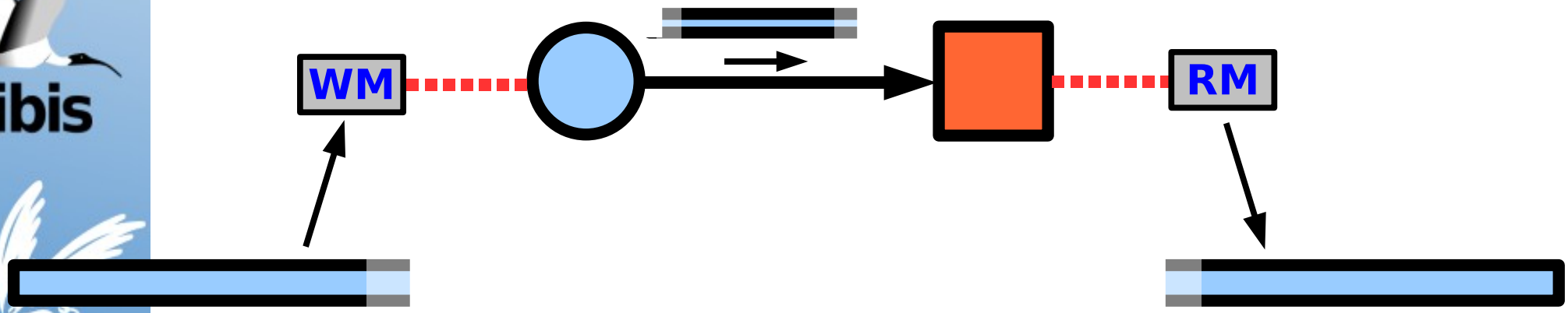


Messages

- Done!

Messages or streams ?

- Message size is unlimited
  - Data may be forwarded at any time
  - Both S. & R. messages alive at same time
  - There's streaming!



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Ibis Serialization

- Based on bytecode-rewriting
  - Adds serialization and deserialization code to serializable types
  - Prevents reflection overhead during (de-)serialization
  - Has fallback mechanism for non-rewritten classes
- Experimented with runtime rewriting

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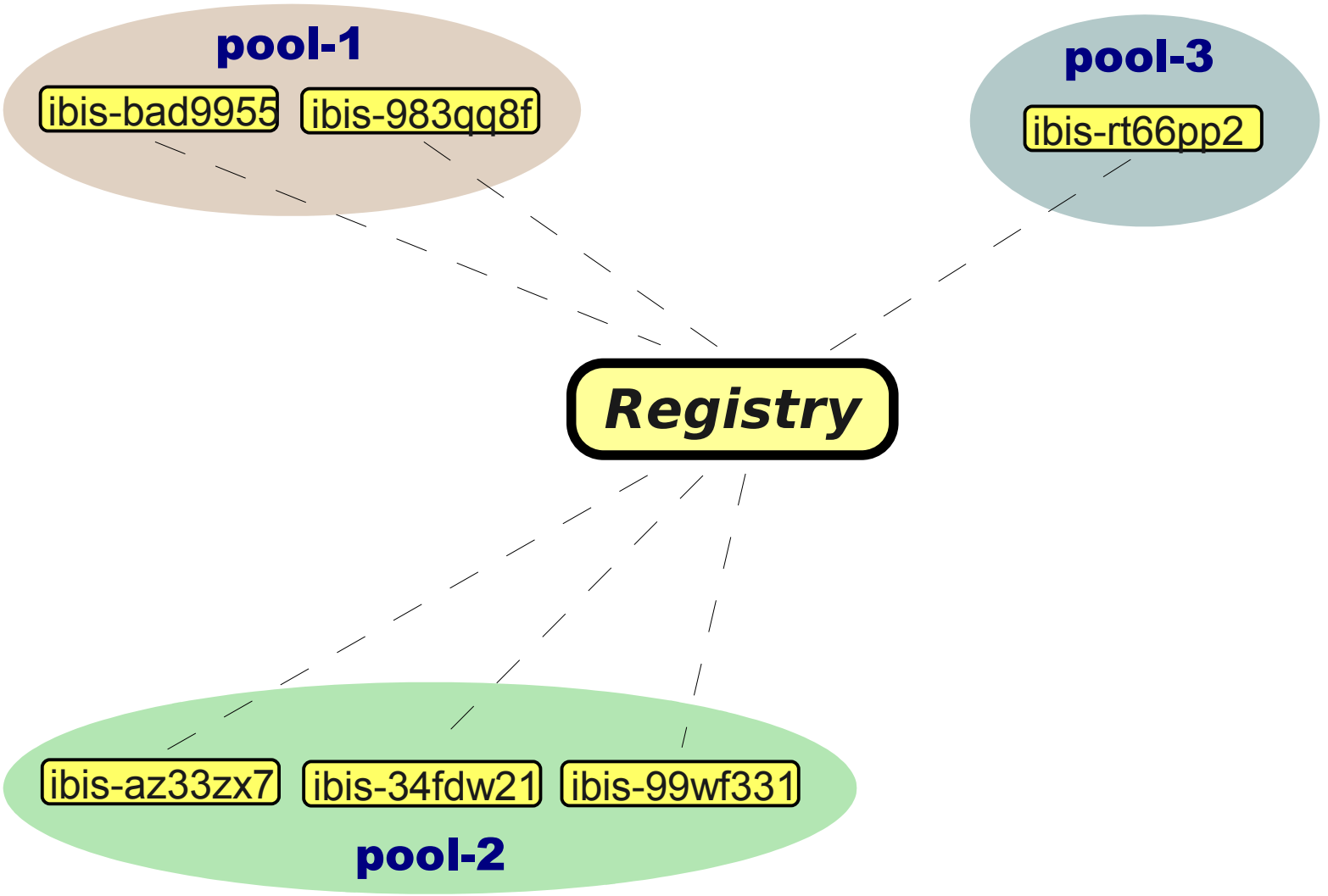
Fault-Tolerance and Malleability

- IPL can provide callback mechanism
  - notifies the application when a machine joins, leaves or crashes
- Implemented using a **registry**
  - server that manages who participates in the application run
- Example shows a centralized version
  - also have broadcast tree and gossiping implementations (improve scalability)

Pools & Malleability



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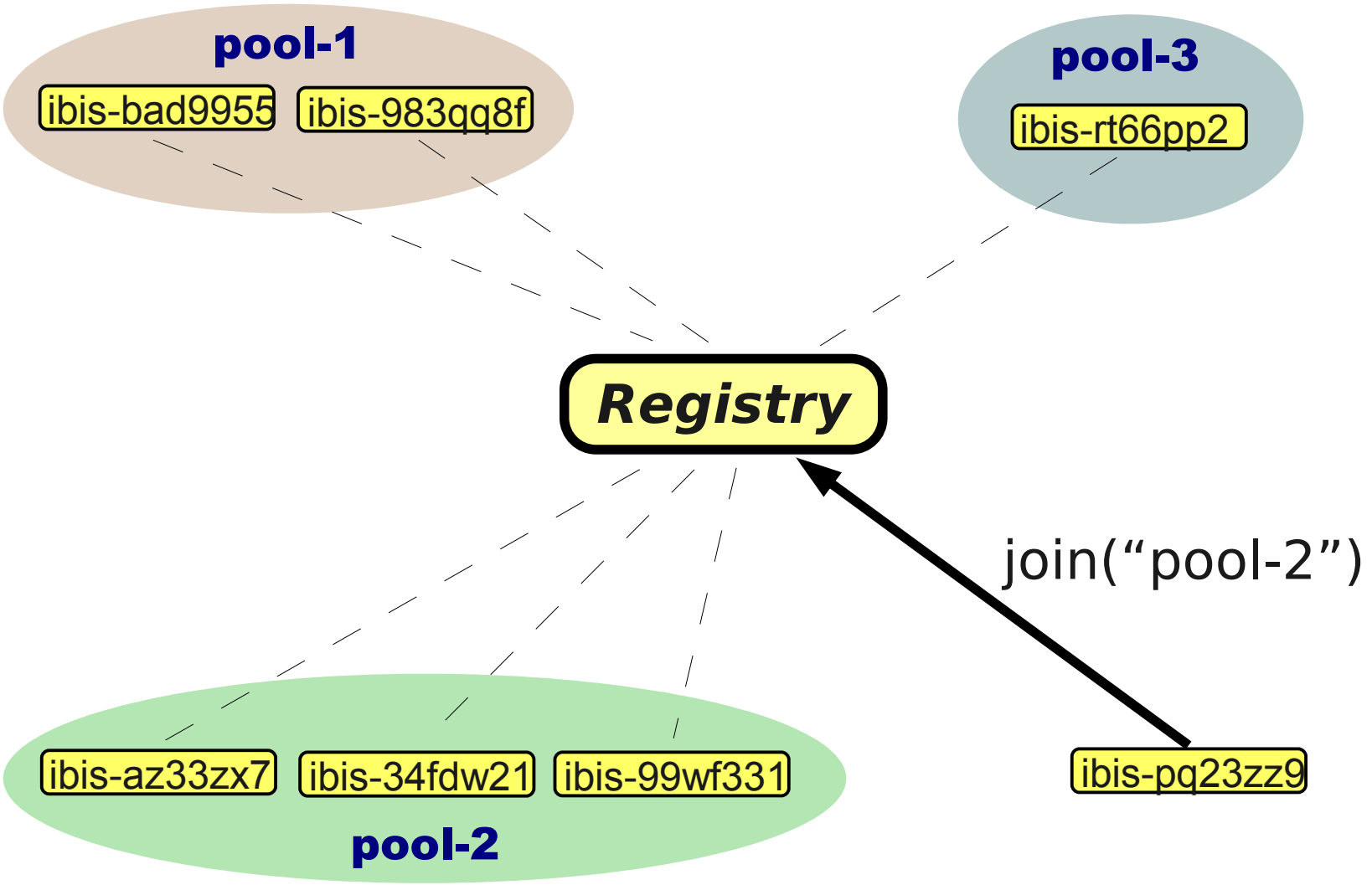

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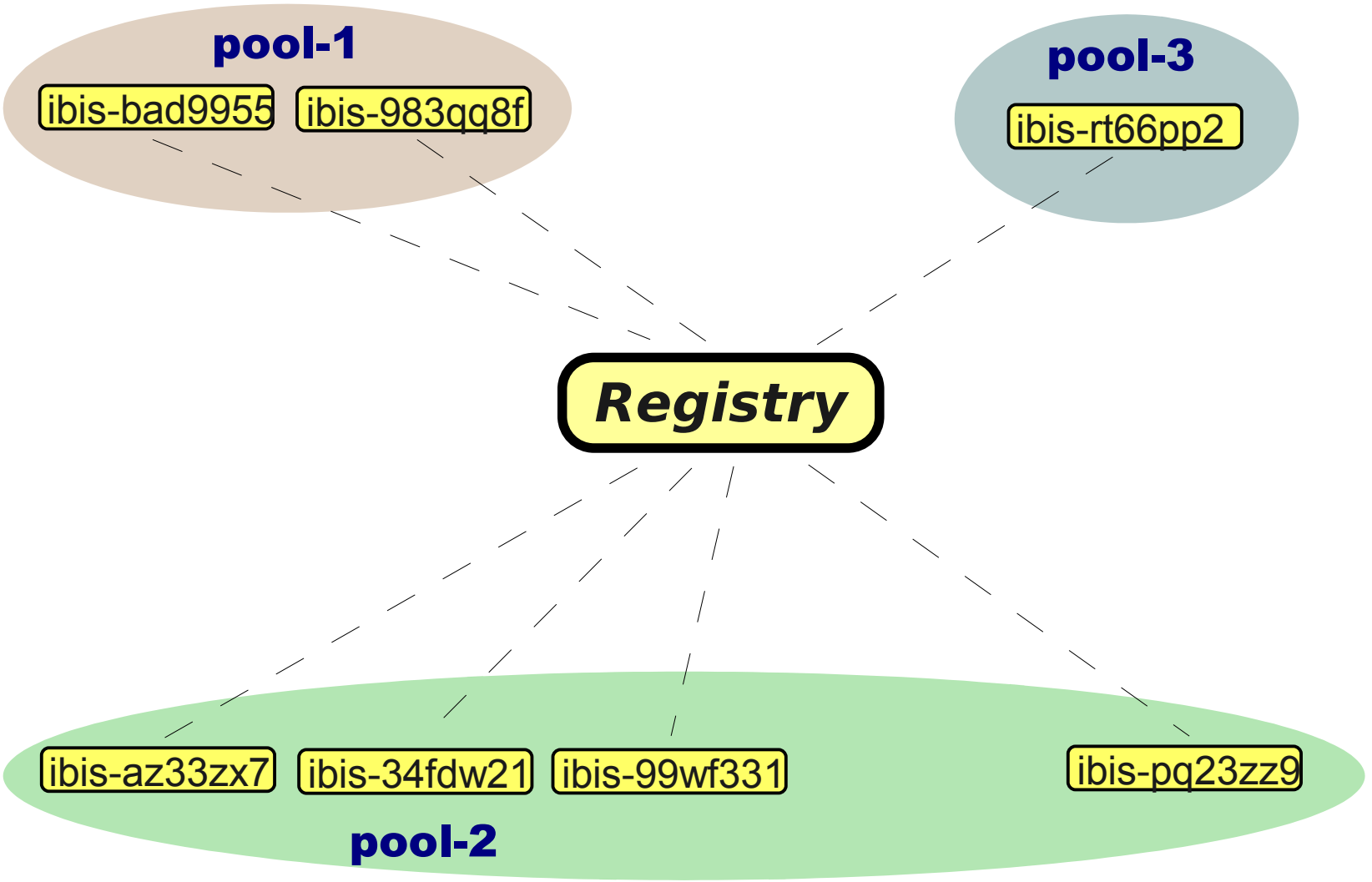

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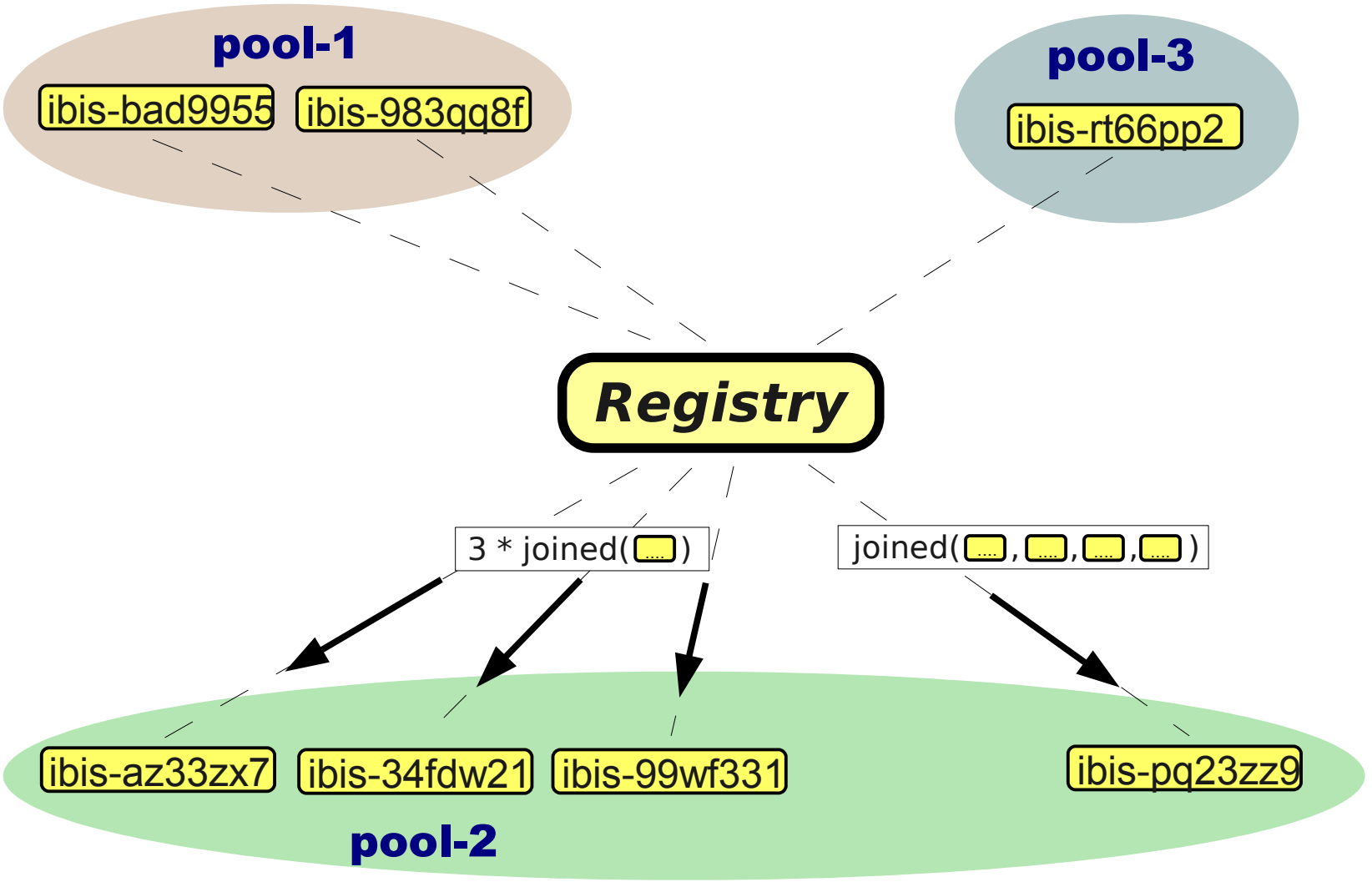

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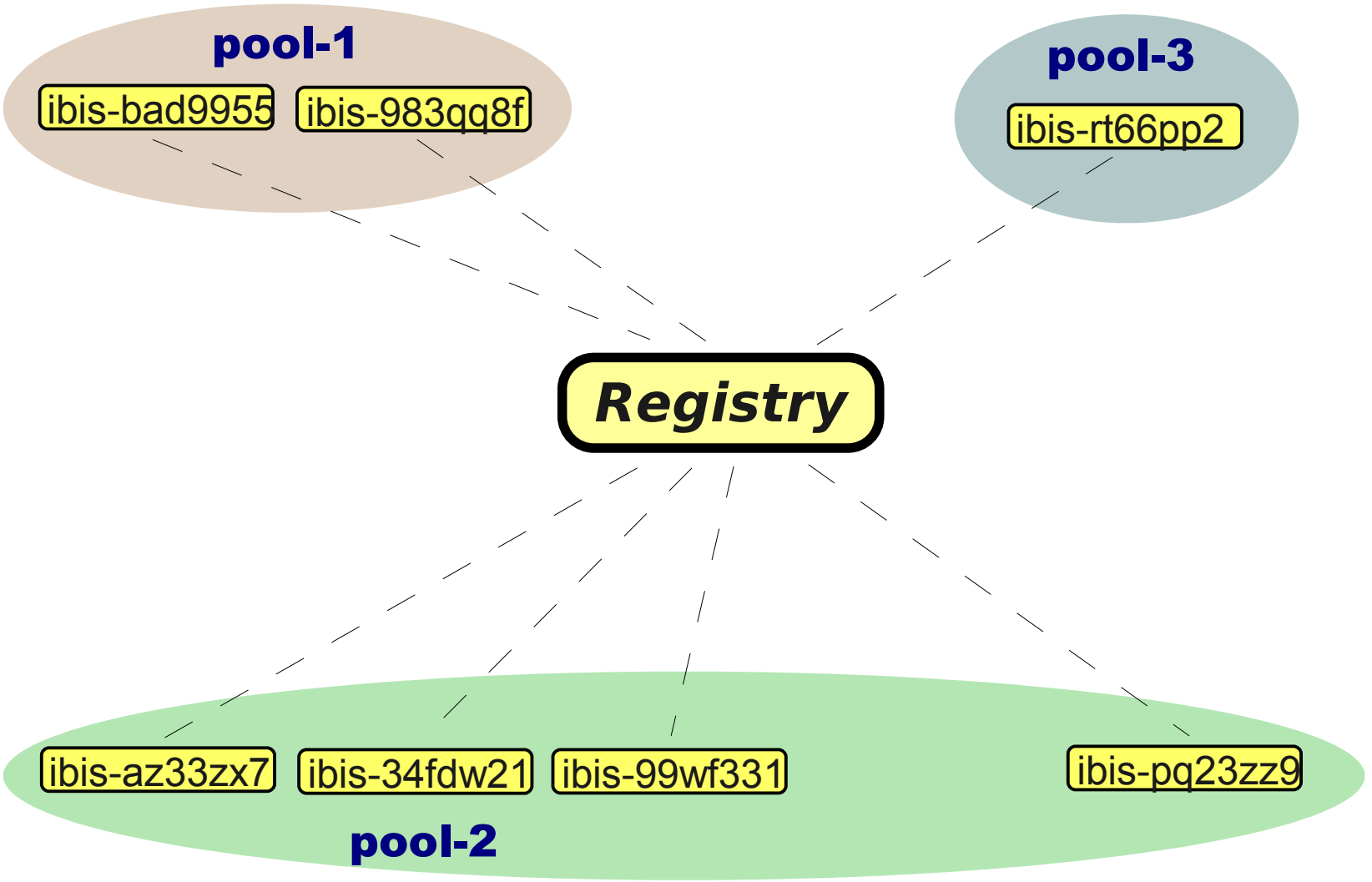

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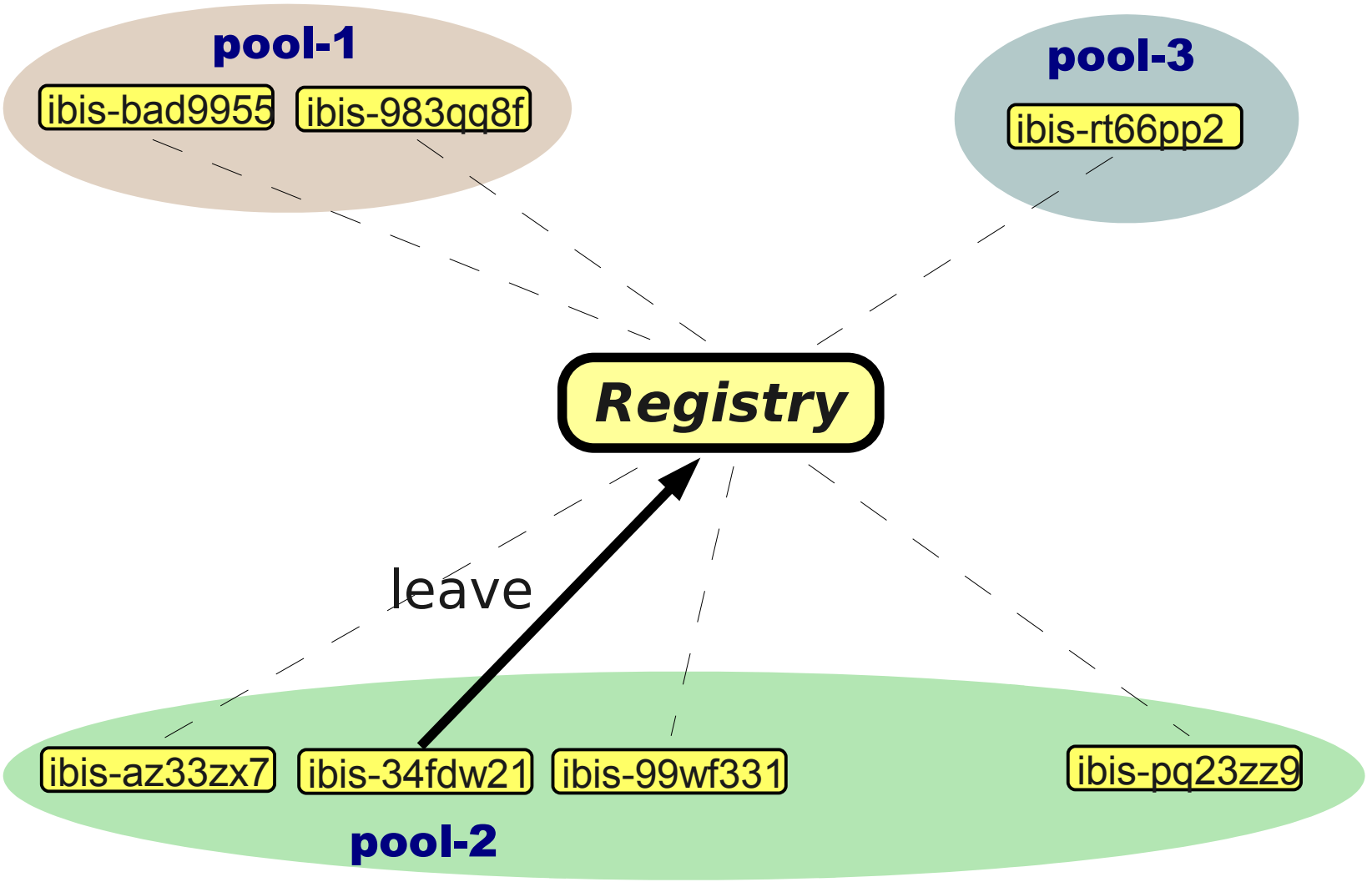

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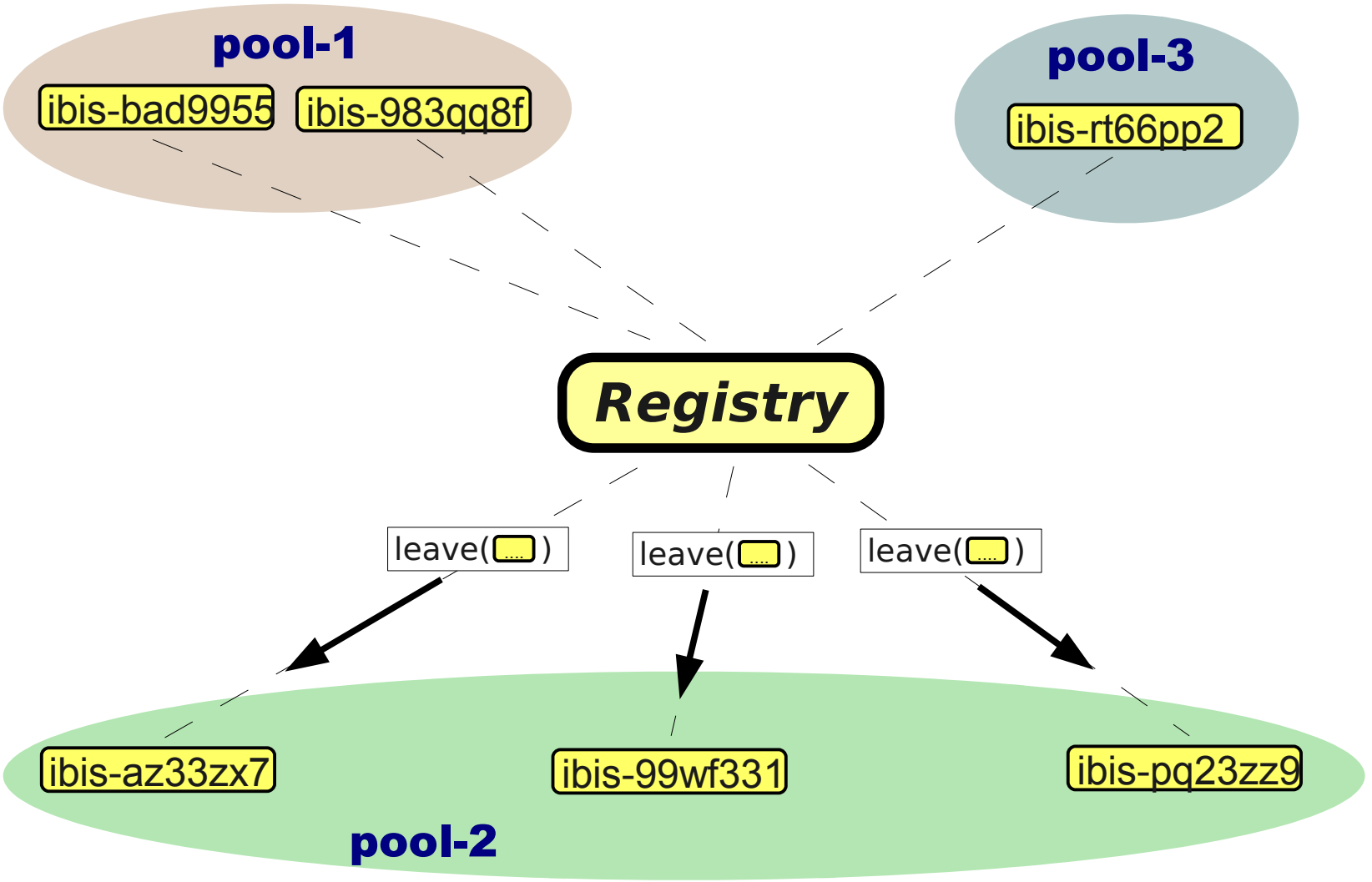

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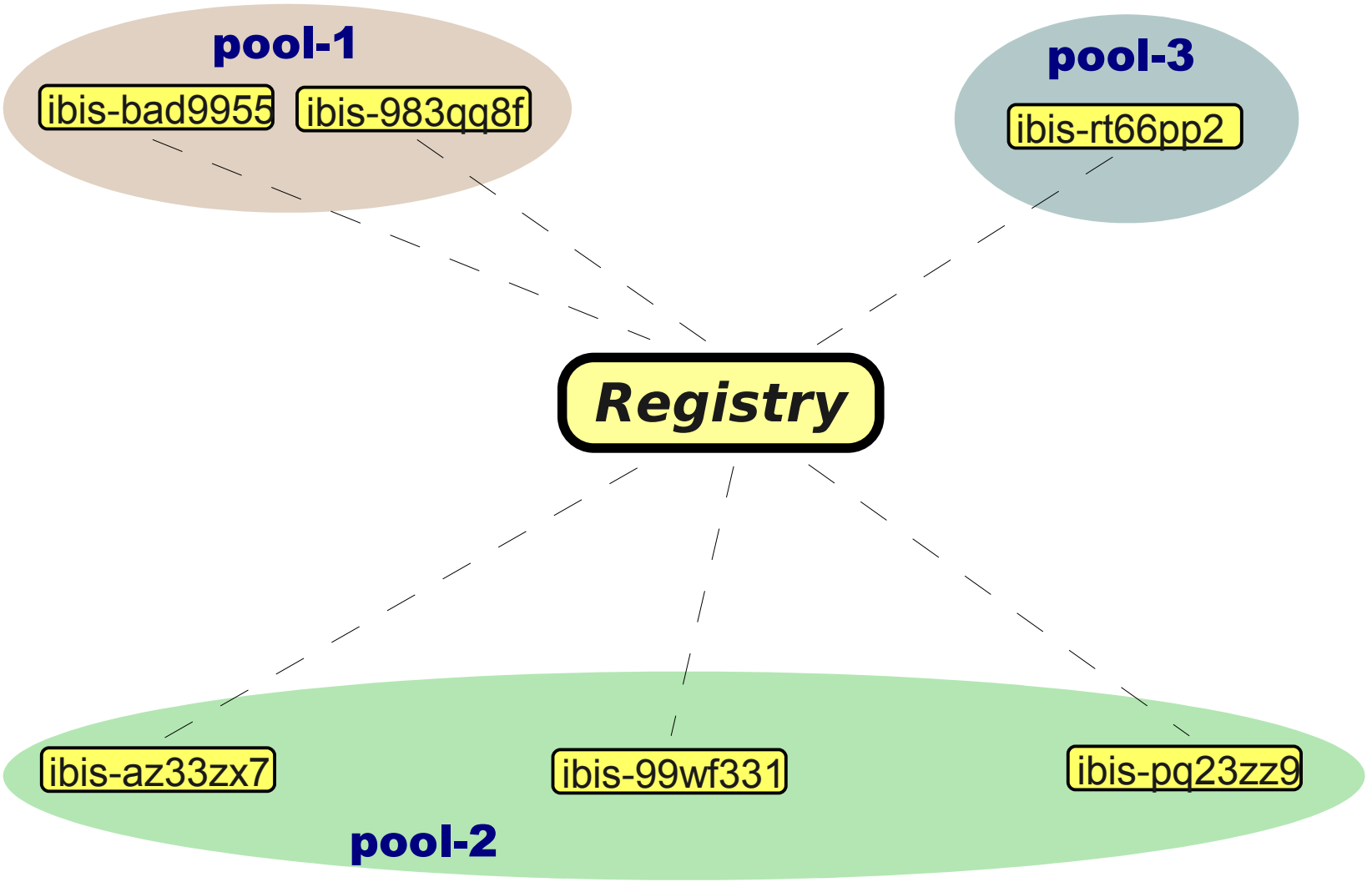

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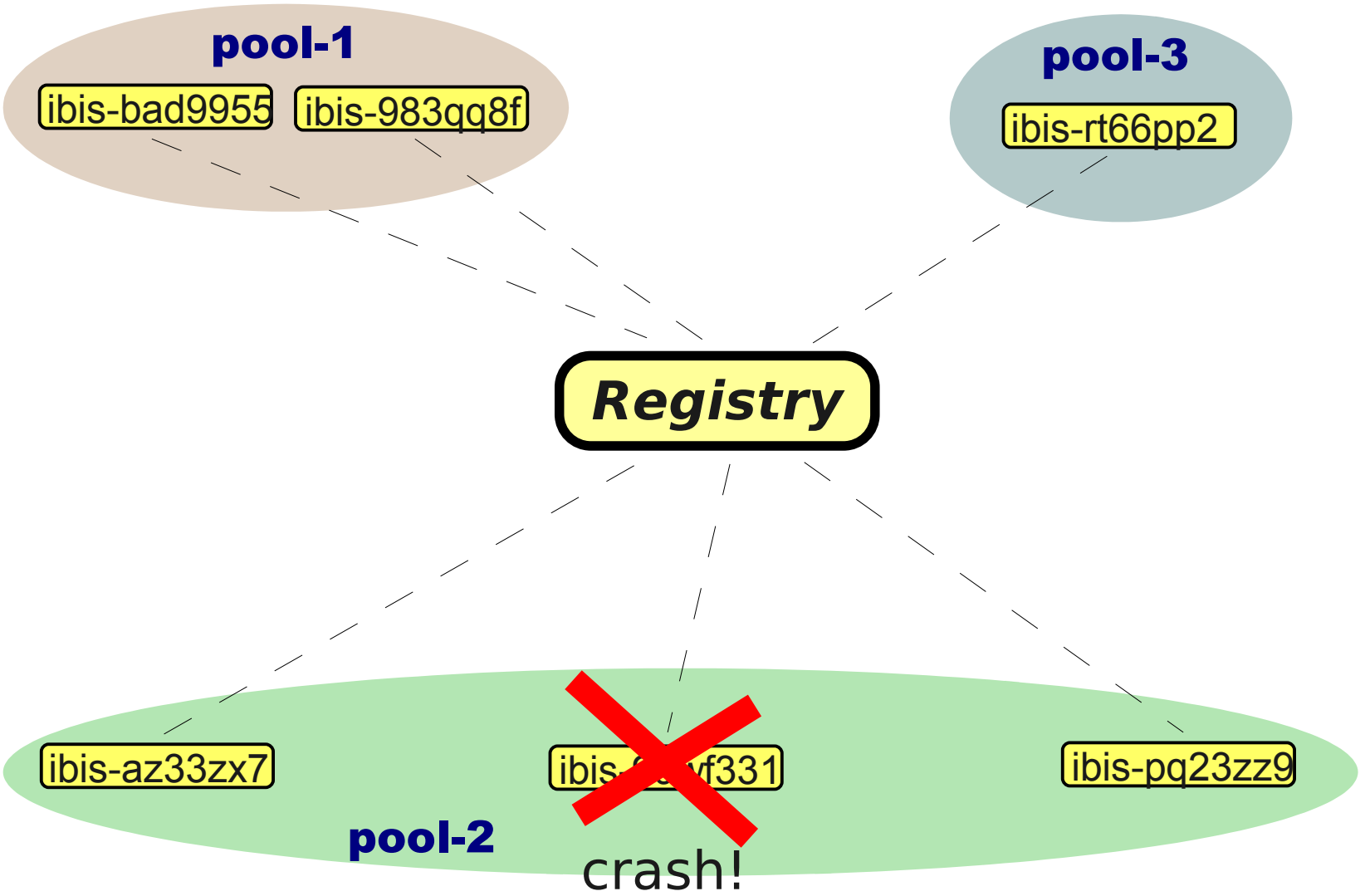

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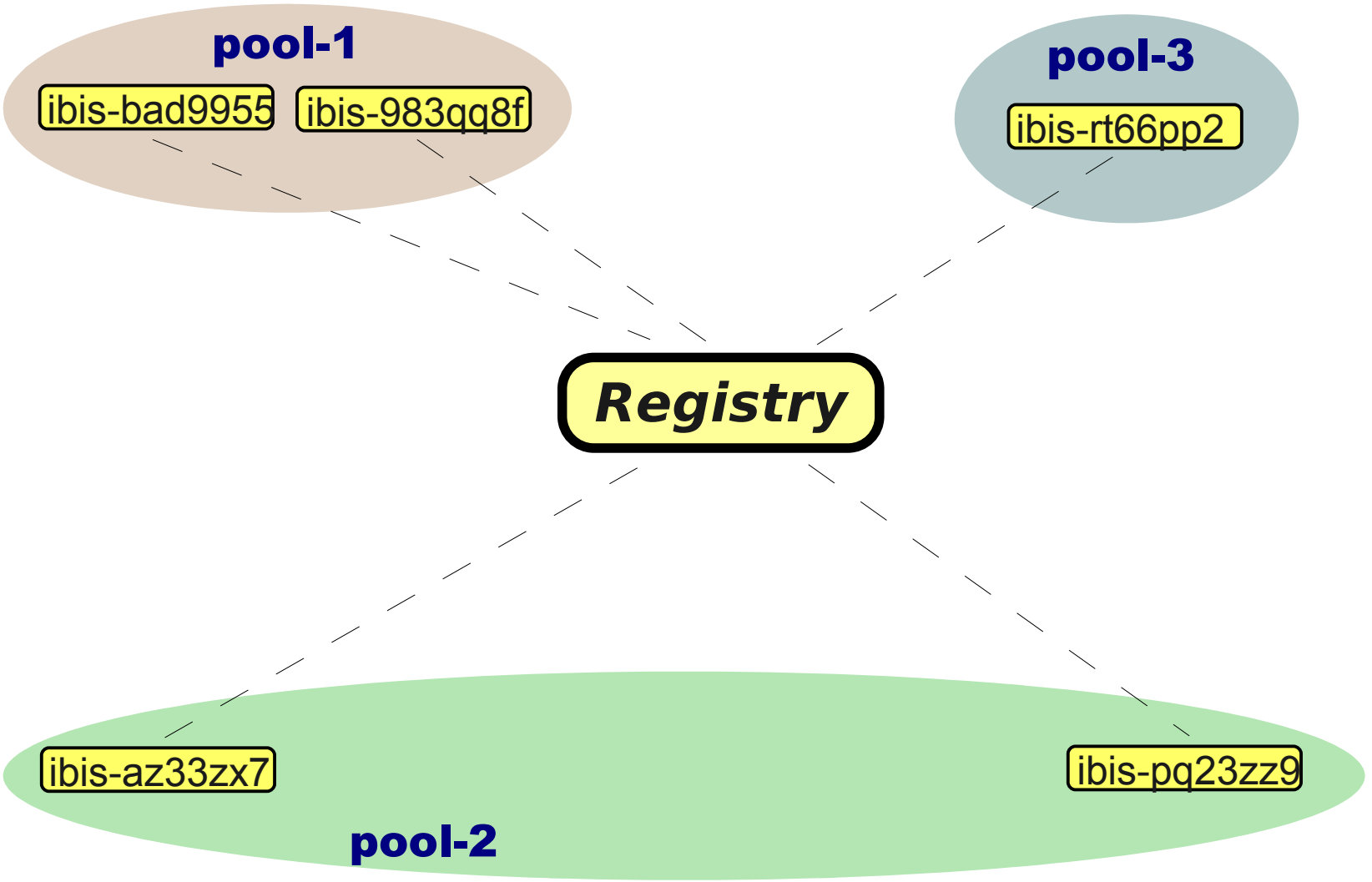

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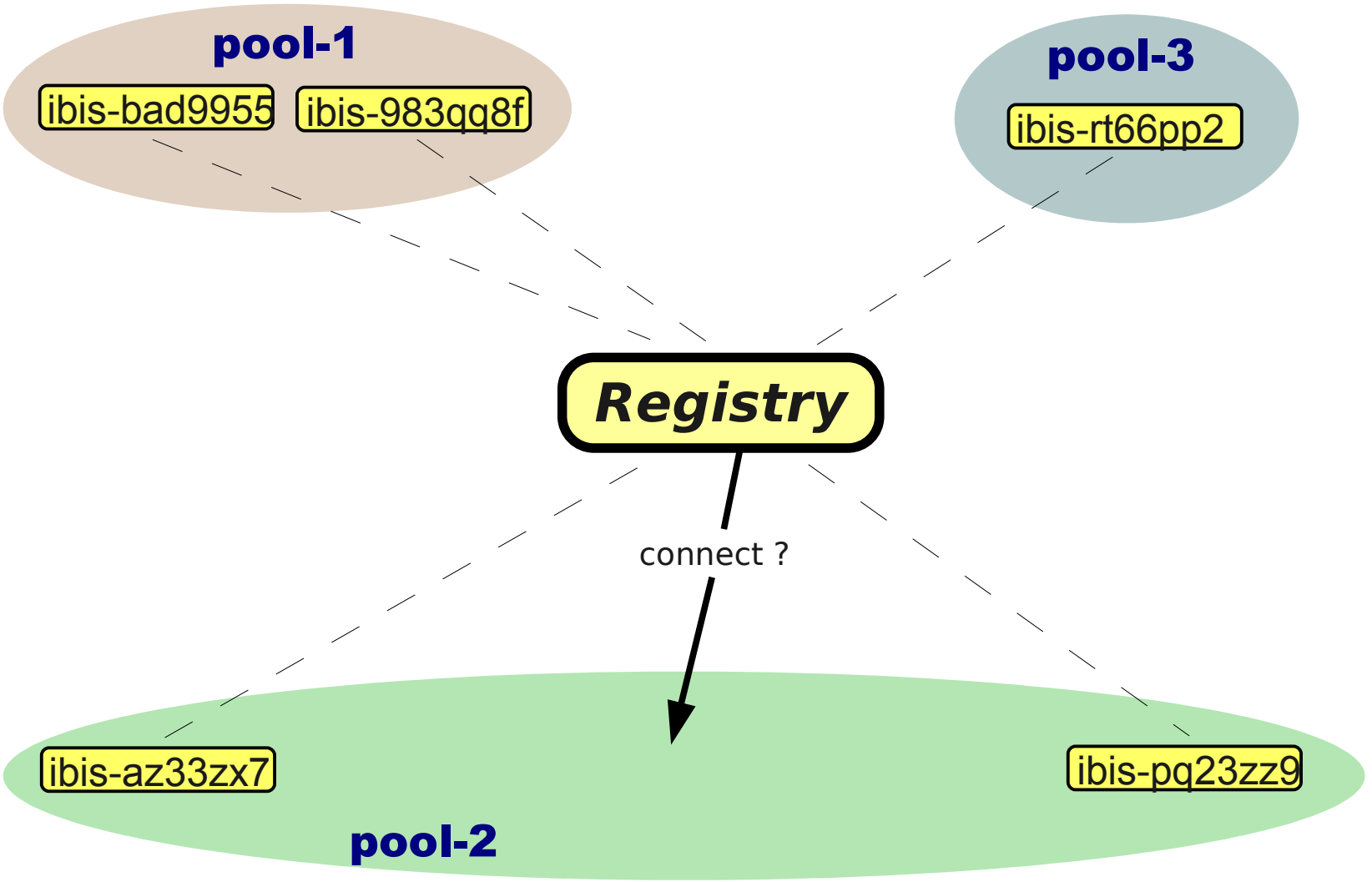

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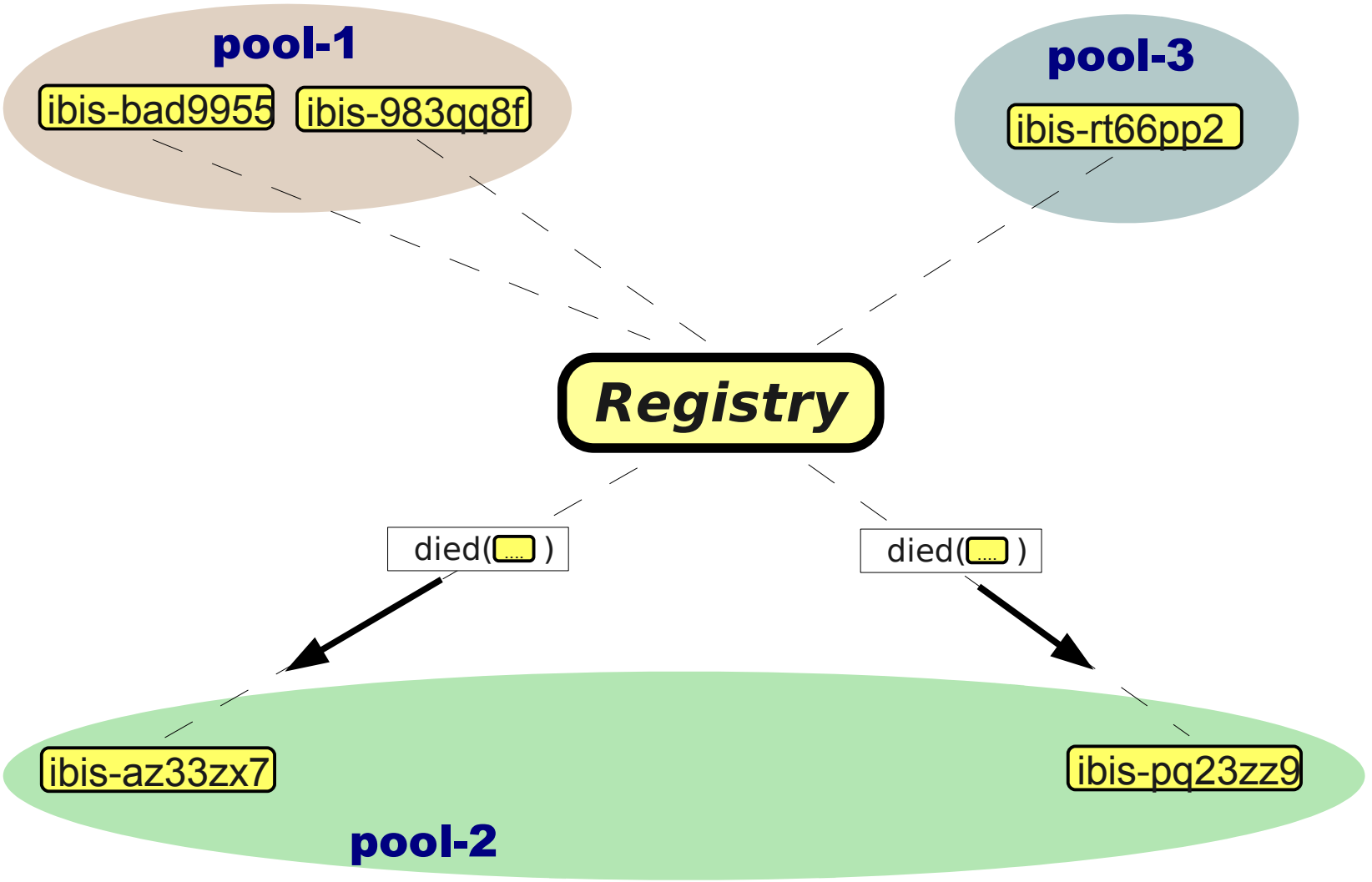

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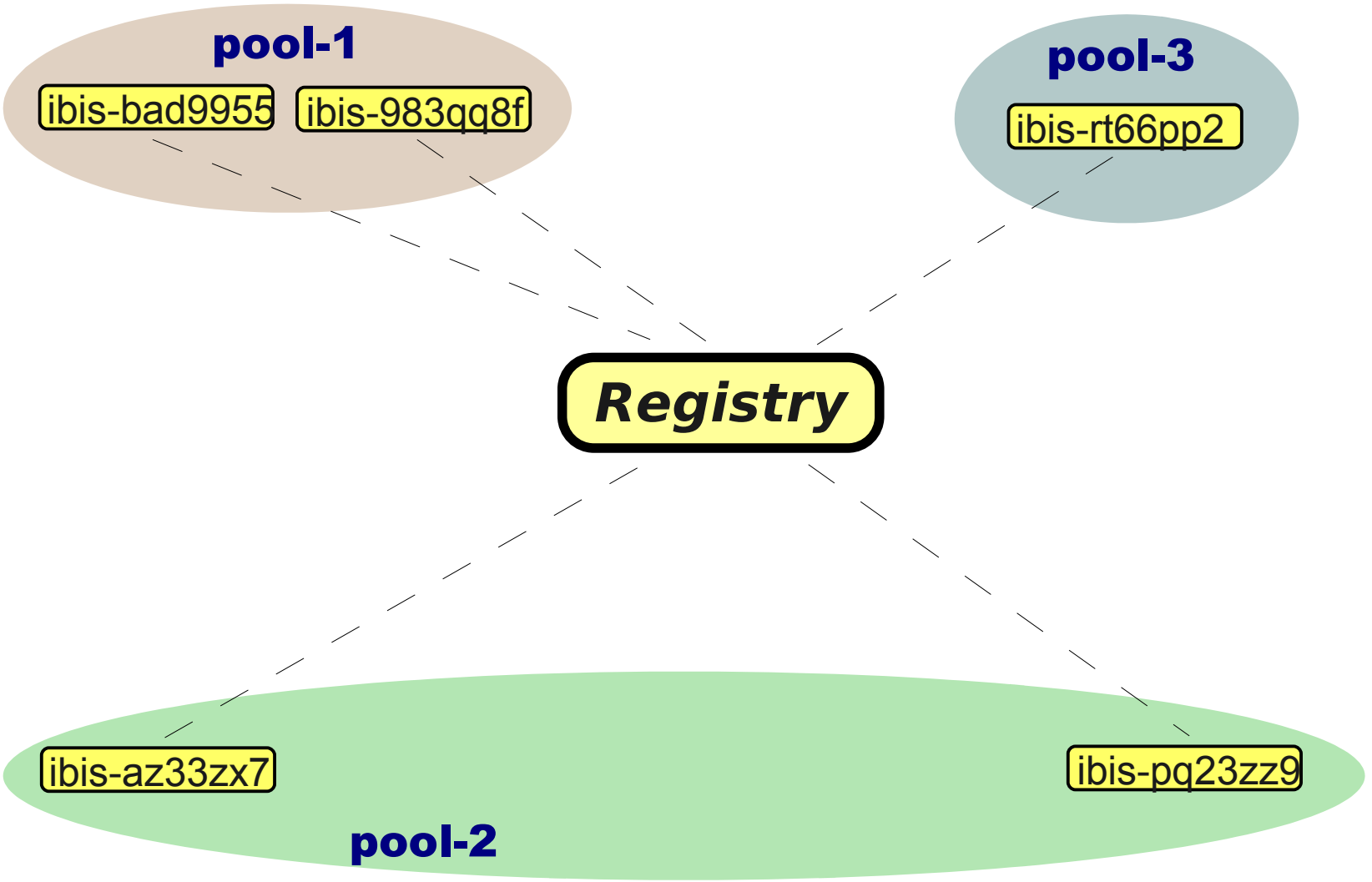

Registry

- Many implementations
  - centralized, broadcast, gossiping, etc.
  - different tradeoffs in complexity, robustness and consistency
- You can select the functionality and consistency that is needed
  - reducing functionality or consistency further improves scalability

Elections

- IPL also offers an 'election'
  - Allows a group to determine who's **special**
  - Ranks don't work in a malleable grid!
- Each election
  - Has a name (String)
  - Produces IbisIdentifier of the winner
  - Is not democratic
  - You can also be 'an observer'

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Summary

- IPL offers an abstract model
  - Connection oriented message passing
  - Hides network details (for portability)
- Supports fault tolerance / malleability
  - **No system-level fault tolerance!**
  - Only offers the means to implement fault tolerance in application / runtime system!
- Higher level models (Satin) can offer transparent fault tolerance

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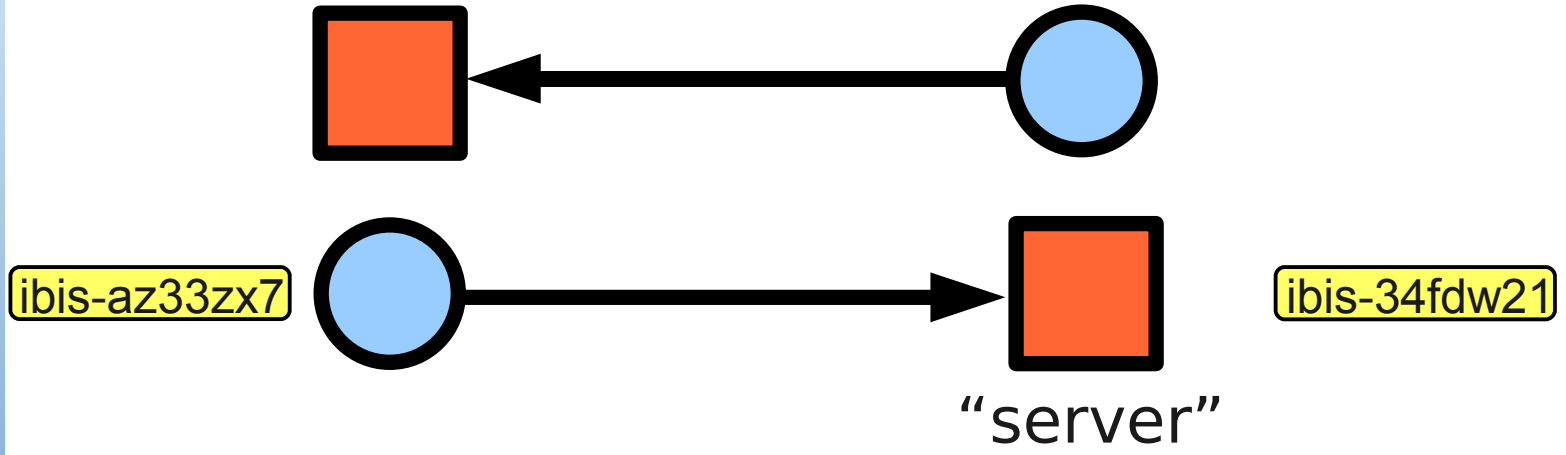
D-Grid

- Groot, GAT gebruikt bij
  - Max Planck inst. (Munchen)
    - Workflow (ProC)
      - Astronomen – simulaties in workflow
      - GUI op GAT
      - Henri weet meer ?
  - Potsdam (Berlijn, Alexander)
    - contactpers. / PR.

Connection setup (1)

Connection setup (2)



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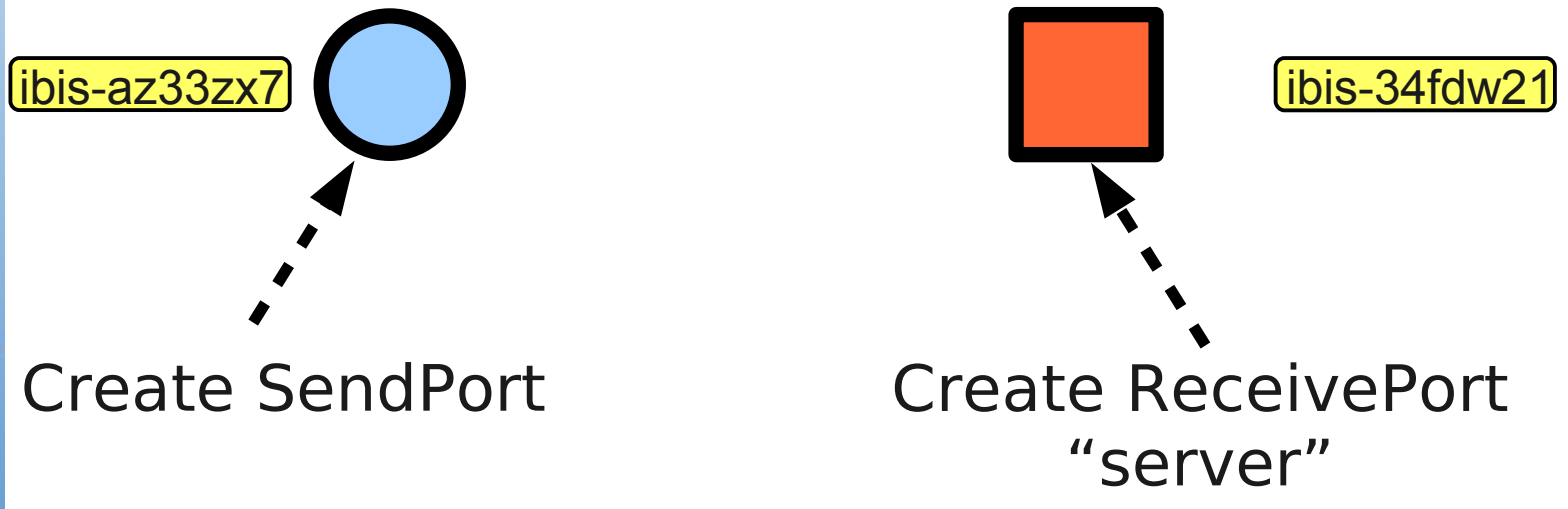

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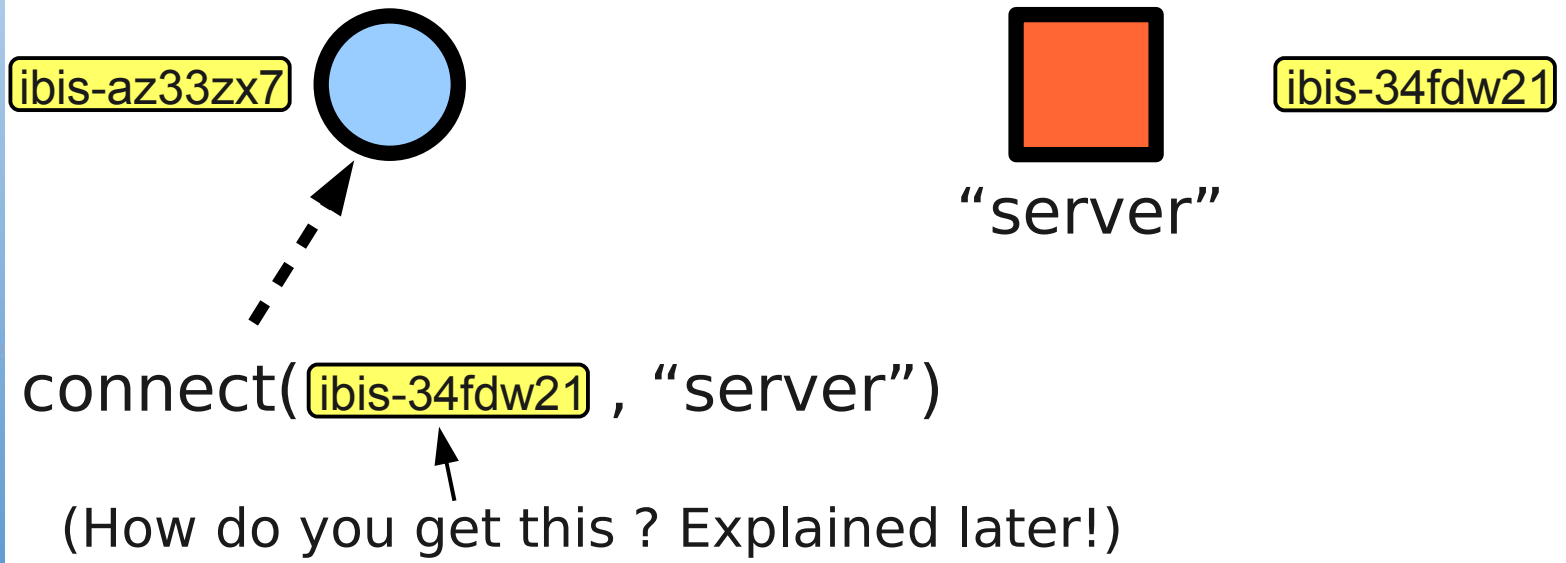

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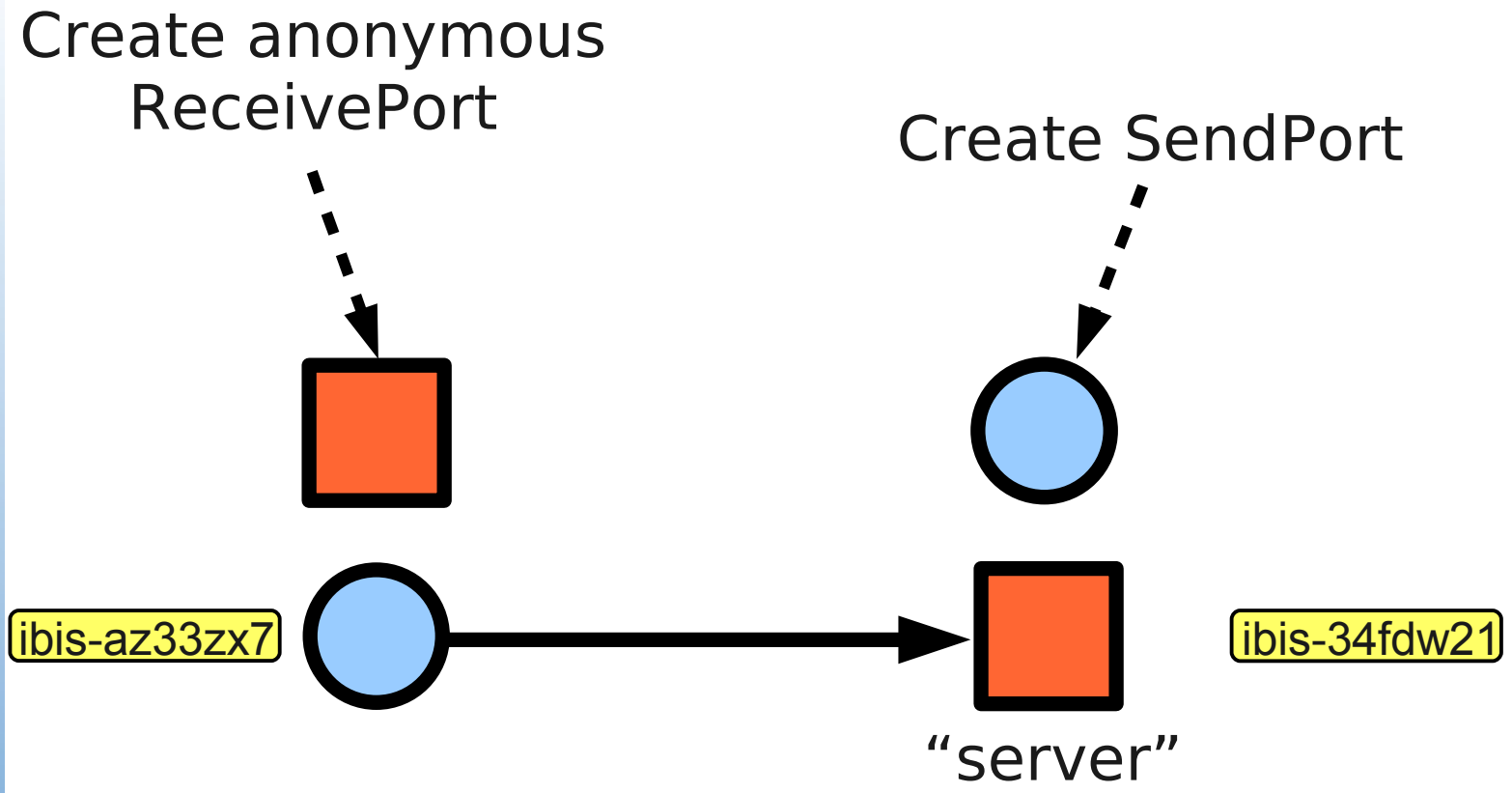

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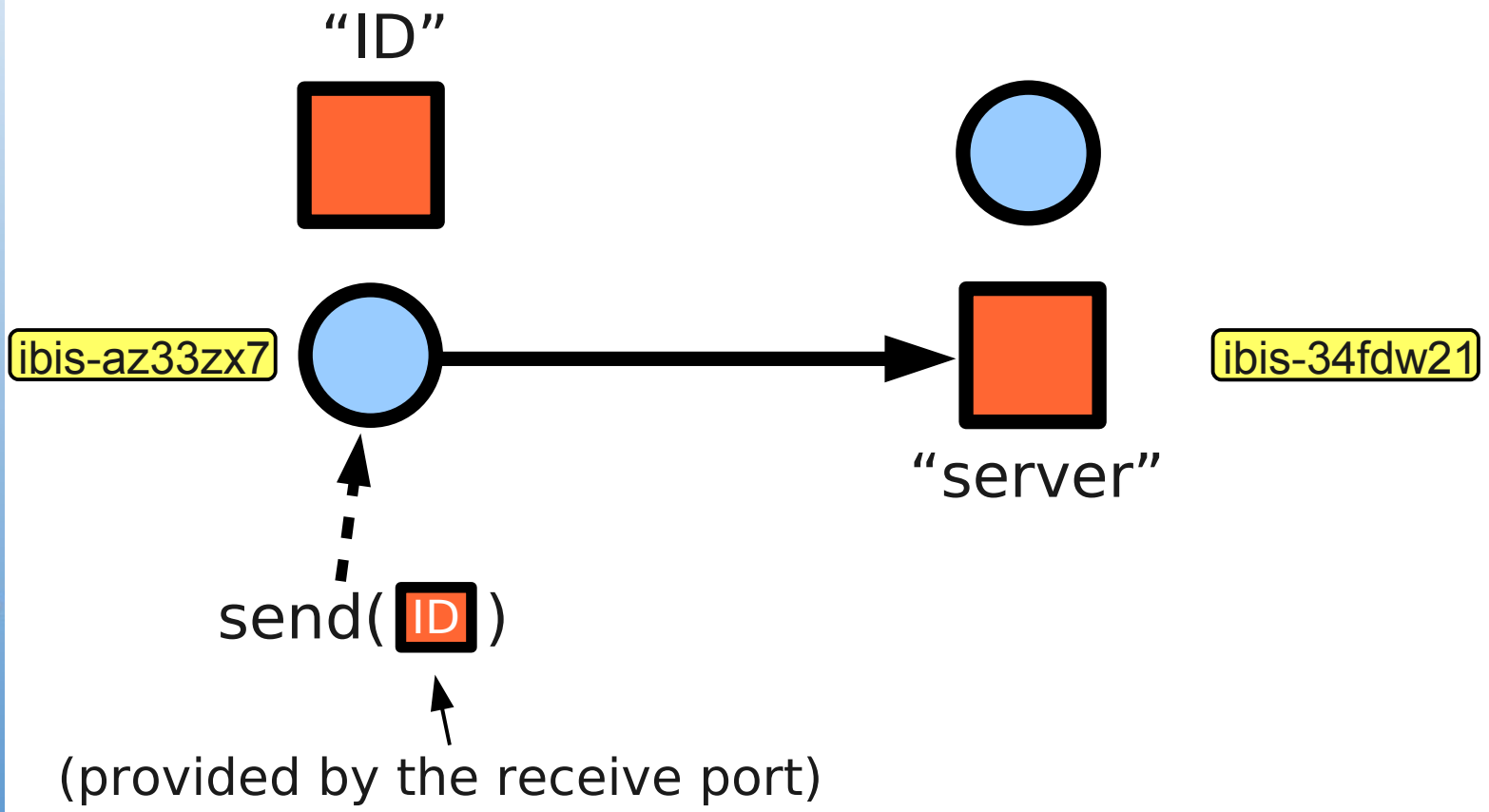

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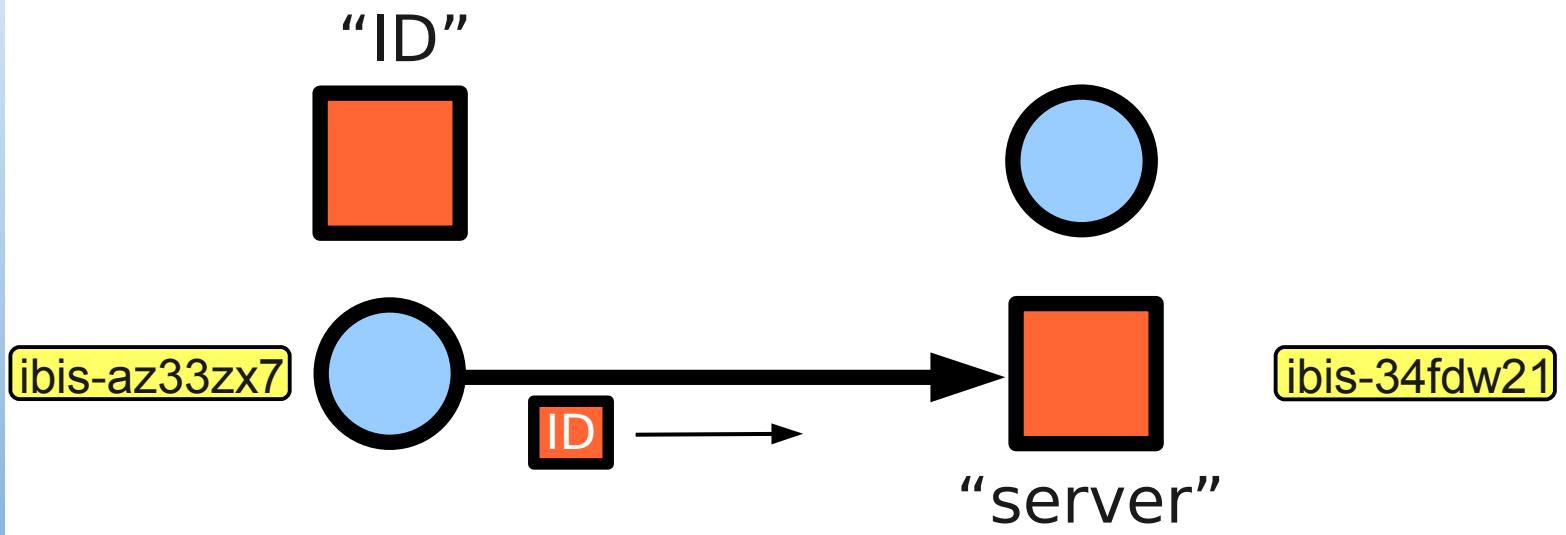

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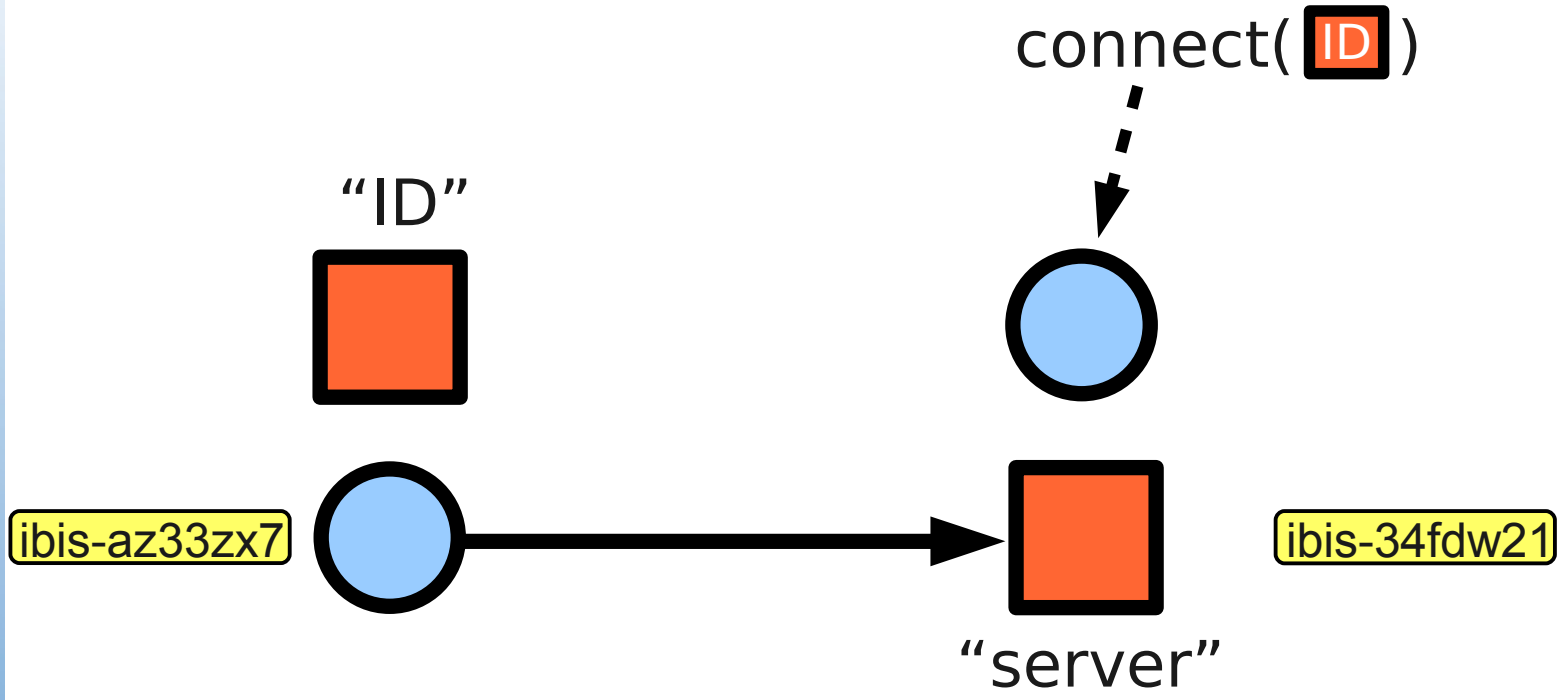
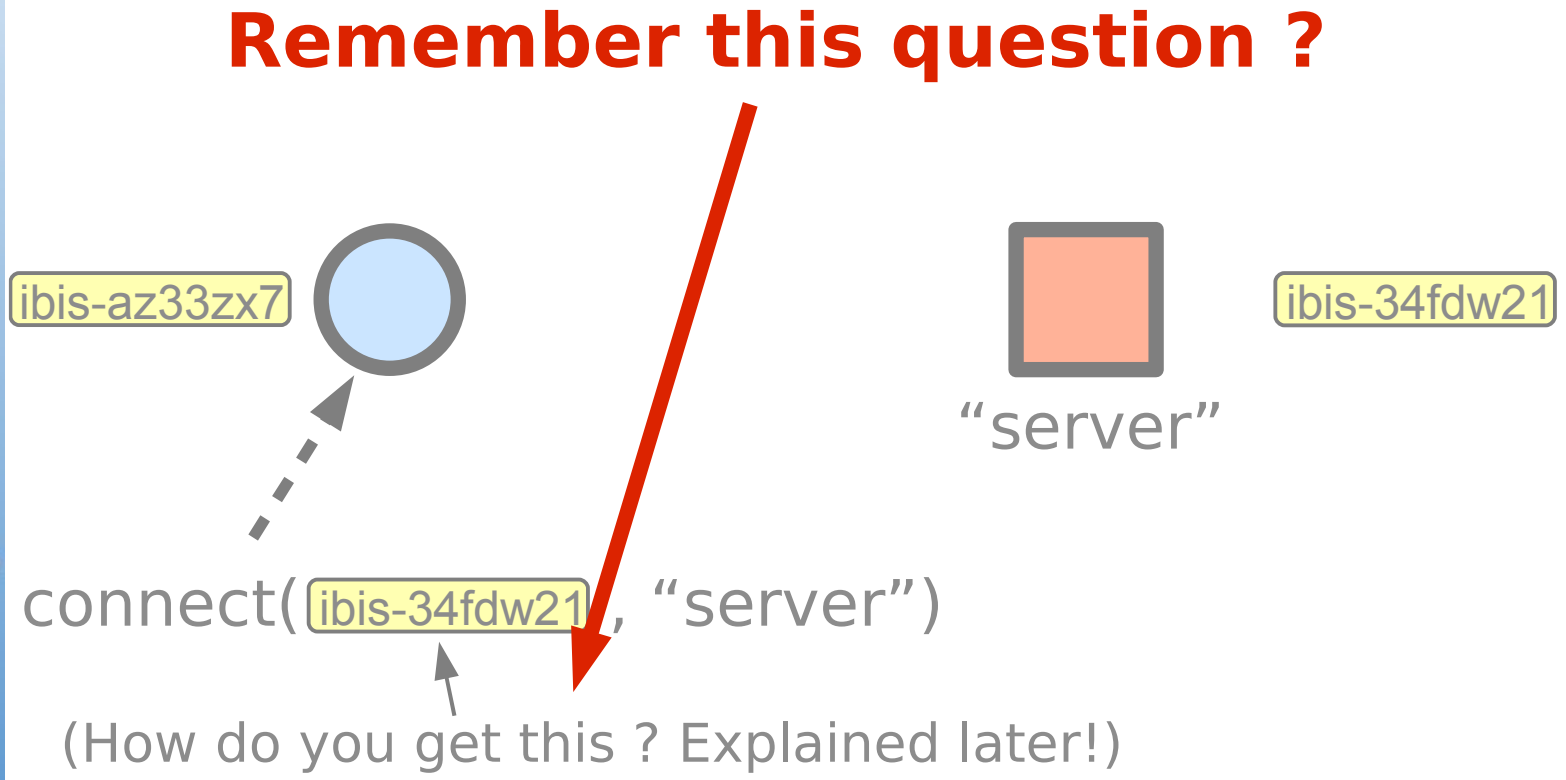


Short Recap

- First create PortType
- PortType creates Send & ReceivePort
  - Type is checked when connecting
- Several ways to connect
  - Abstact addressing
- Use Messages to communicate
  - Allows streaming
  - 3/4 types of serialization

Connection setup (1)



IbisIdentifiers

- In a parallel/distributed application
  - Each process has an IPL instance
  - Each instance has an **IbisIdentifier**
- IbisIdentifier:
  - Uniquely identifies an IPL instance
  - Abstracts away from the implementation
    - e.g. hostnames, IP addresses, MPI-ranks, etc.
  - Makes your application a bit more portable

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Crashes and Malleability

- Membership information
  - Can subscribe to information
    - Updates when Ibis instances join or leave
  - Useful for determining who's participating
    - Also used for fault-tolerance
- Ibis instances are part of a **pool**
  - Either variable size or fixed (create-once)
    - Fixed used by 'legacy' MPI-type applications

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