Building a robust distributed system: some lessons from R-GMA

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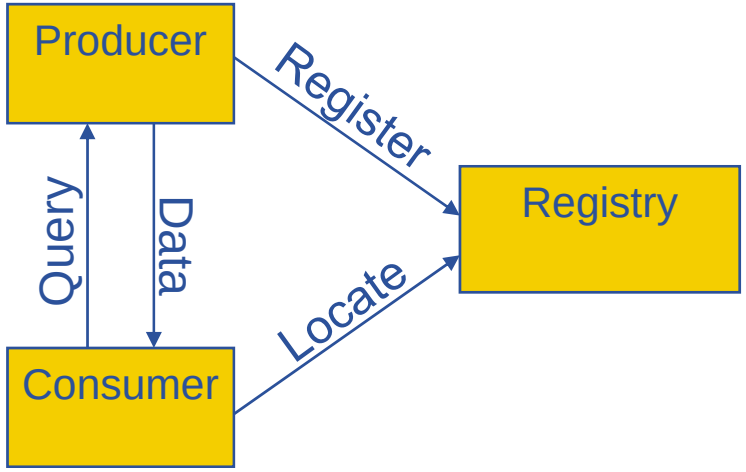
Overview

- **Based on talk at CHEP-07, Victoria, Canada, Sep 2007**

- **GMA and R-GMA overview**
- **Managing Memory Usage**
- **Buffers**
  - Consumer
  - Primary producer
  - Secondary producer
- **Loss of control messages**
- **Replication**
  - Schema
  - Registry
- **Conclusions**

GMA

- **Defined by the GGF**
  - Now OGF
- **3 Components**
  - Producer
  - Consumer
  - Registry

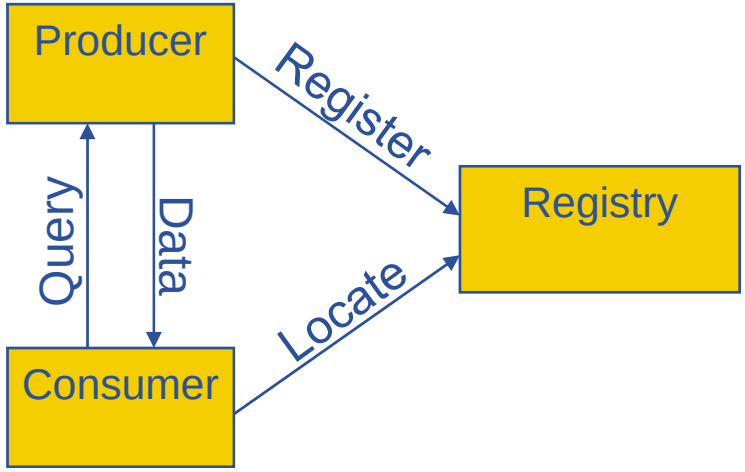


- **Real system needs to tie down message formats**
  - This has been done by R-GMA

- **The INFOD-WG at GGF**
  - IBM, Oracle and others have defined a GMA compliant specification

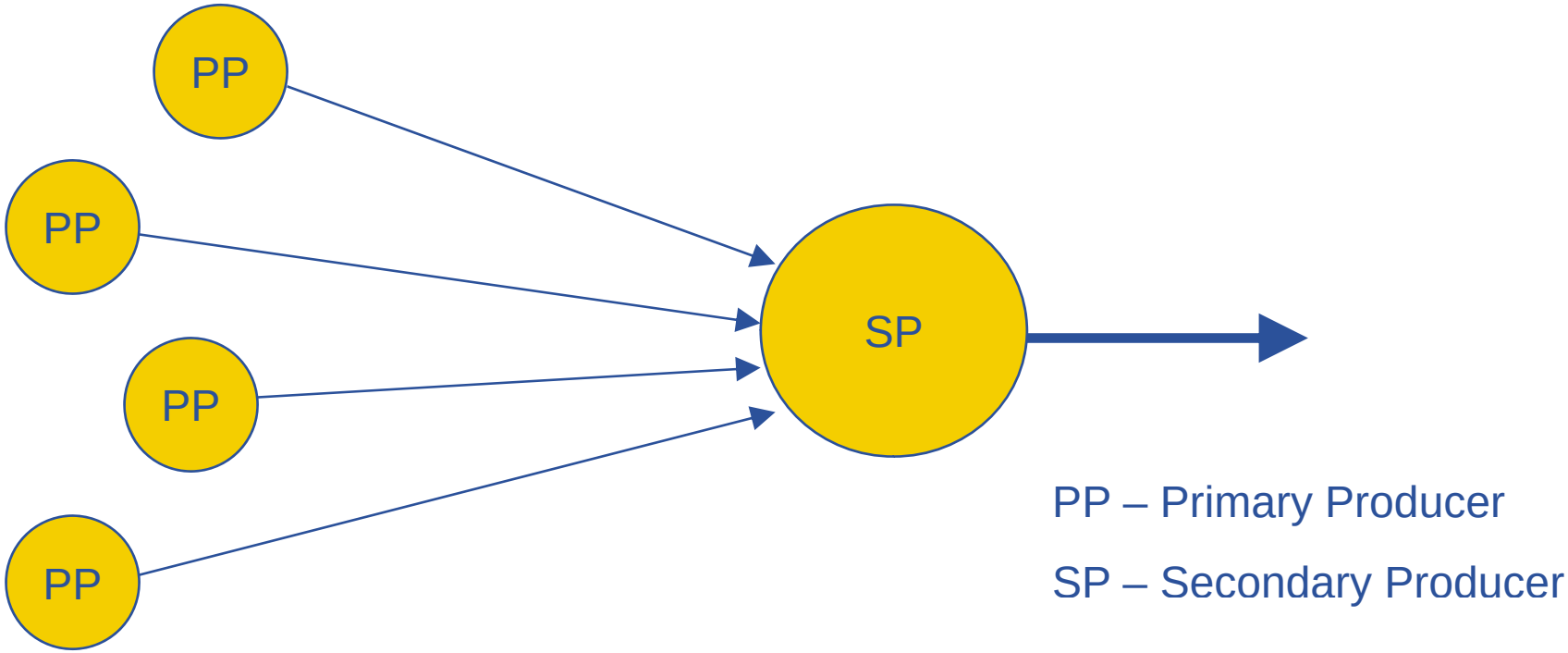
R-GMA

- Relational implementation of GMA
- Registry is hidden
- Provides a uniform method to publish and access both information and monitoring data
- All data has a timestamp, enabling its use for monitoring
- Easy for individuals to define, publish and retrieve data



R-GMA Producers

- **Primary – source of data**
- **Secondary – republish data**
  - Co-locate information to speed up queries
  - Reduce network traffic



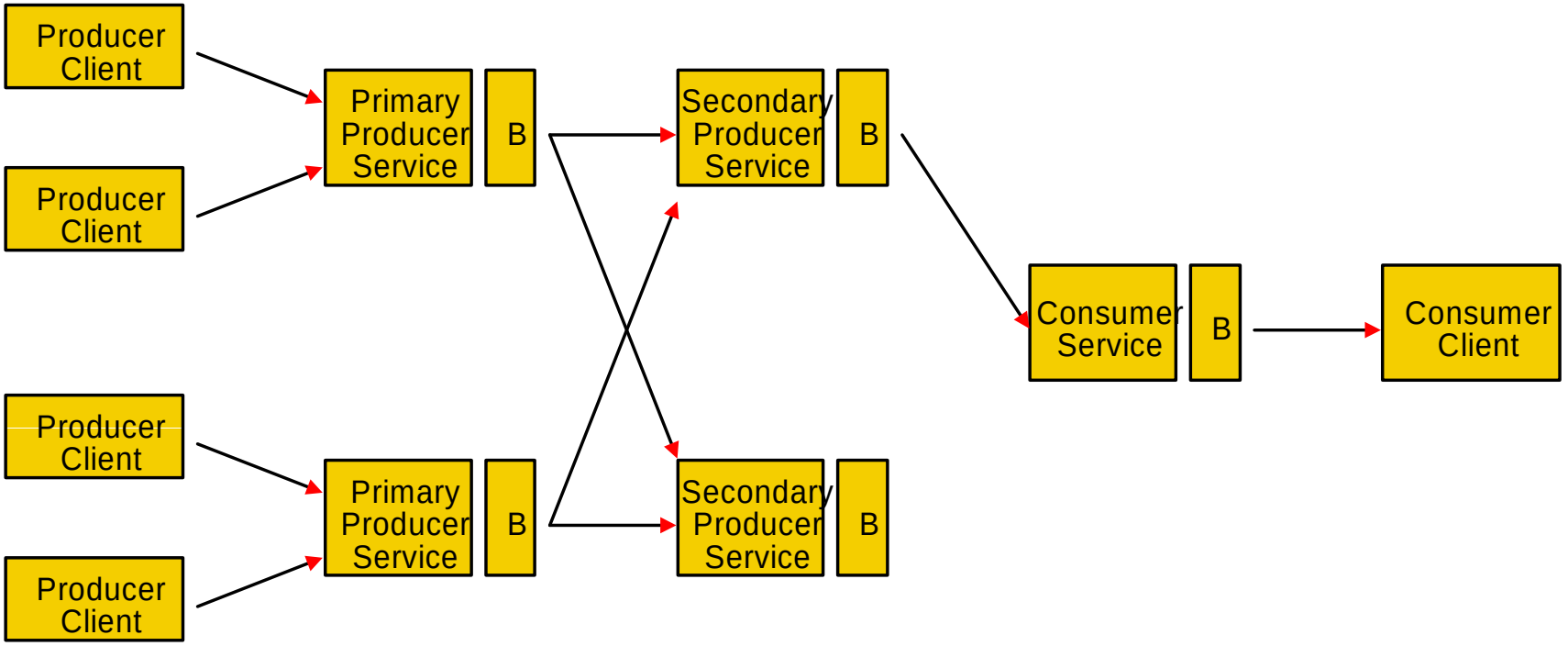
Three points in the R-GMA evolution

- **EDG**
  - corresponding to the version developed within EDG.
- **EGEE-I**
  - for the version deployed in gLite 3.0
- **EGEE-II**
  - for the version that will be ready near Christmas 2007 as upgrades to gLite 3.1
  - Designed to be reliable

Managing Memory Usage

- **R-GMA may have varying amounts of memory available**
  - May share servlet container (Tomcat) with other servlets
  - JVM may be badly configured
- **EGEE-II solution**
  - Use JDK 5's threshold notification from a MemoryMXbean to detect the low memory condition
  - When memory is low an RGMABusyException returned for all user calls that may take extra memory
    - inserting data into the system
    - creating new producer or consumer resources
- **We try to be fair**
  - If you behave reasonably you should not be penalised
  - If problem is caused by too many reasonable demands must reject requests with the RGMABusyException.

Avoiding bottlenecks in the data flow



- **Buffers are shown “B”**
  - Primary producer
  - Secondary producer
  - Consumer

Primary Producer Buffering - problem

- **Problem only exists with memory storage**
  - Latest store to answer latest queries
    - Must hold tuples up to their LRT
  - History store for history and continuous queries
    - Must hold enough tuples to satisfy the history retention period
    - Must hold tuples for which delivery to existing continuous queries has not been attempted.

Primary Producer Buffering - solution

- **EGEE-I solution**
  - RGMABufferFullException which is thrown when a producer tries to publish a new tuple and the producer has exceeded a server defined limit.
  - Works most of the time
- **EGEE-II extra**
  - We have the RGMABusyException to fall back on.

Consumer Buffering - problem

- **Consumer has a buffer for each client where the results of the query are stored until they are popped**
  - If the application is slow to pop() then buffers can fill up.
  - Cannot send an RGMABusyException to a pop() as this call reduces memory use.

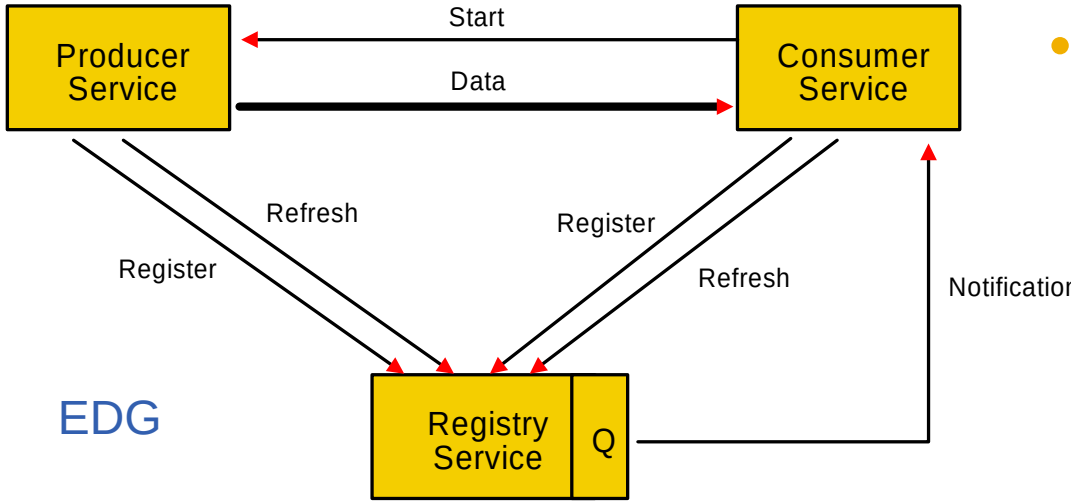
Consumer Buffering - solution

- **EGEE-I solution**
  - Allocate each instance a certain amount of memory
  - When this is full data are written to disk
  - If allocation on disk runs out we close the consumer.
  - This allows us to cope with peaks of data and is working well
- **EGEE-II solution**
  - Similar to above but send overflow to RDBMS instead of disk
    - Slower but with only 20% of the code

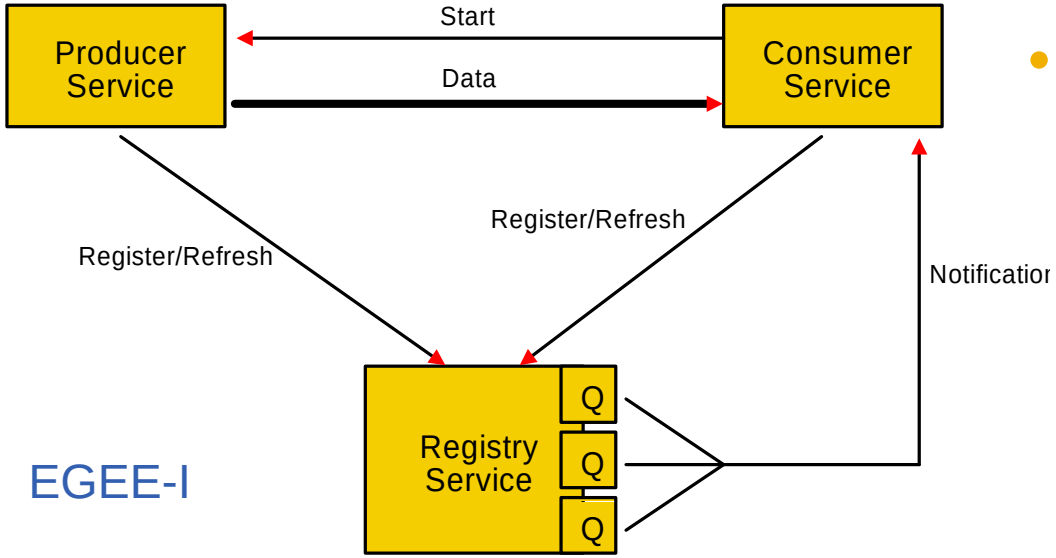
Secondary Producer Buffering

- **In EDG and EGEE-I designs the secondary producer was made up of consumers and one producer.**
- **In the EGEE-II design incoming data are stored directly in the tuple store.**
- **A memory based tuple store can grow very large but nobody to send an RGMABusyException to.**
- **For this reason we do not generally recommend using memory based tuple stores for secondary producers.**
- **Will close the secondary producer when unable to deal with memory demands implied by retention periods.**
  - This will be added to the servlet code that would normally be sending the RGMABusyException.
  - Not “fair” – but simple

Coping with loss of control messages

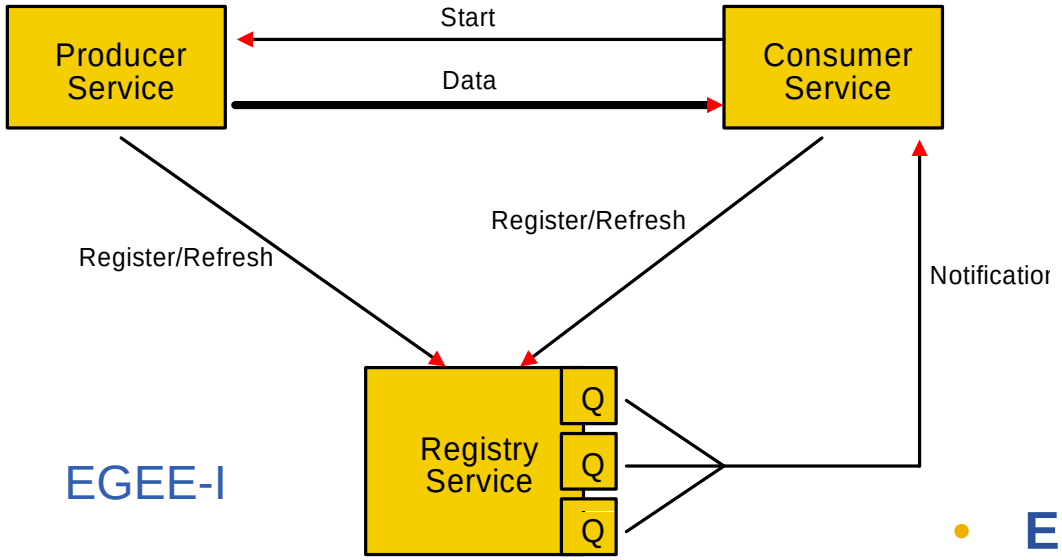


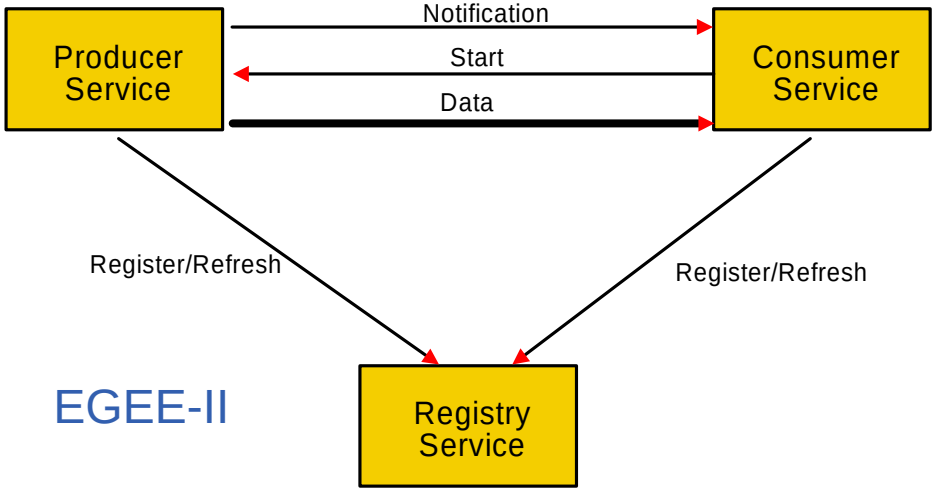
- **EDG**
  - Register once
  - Refresh periodically
  - Only register results in notification and start
  - Network problems can block everything



- **EGEE-I**
  - Use register as refresh
    - No longer need messages to get through
    - But much more traffic
  - Split queue into slow medium and fast queue

Coping with loss of control messages



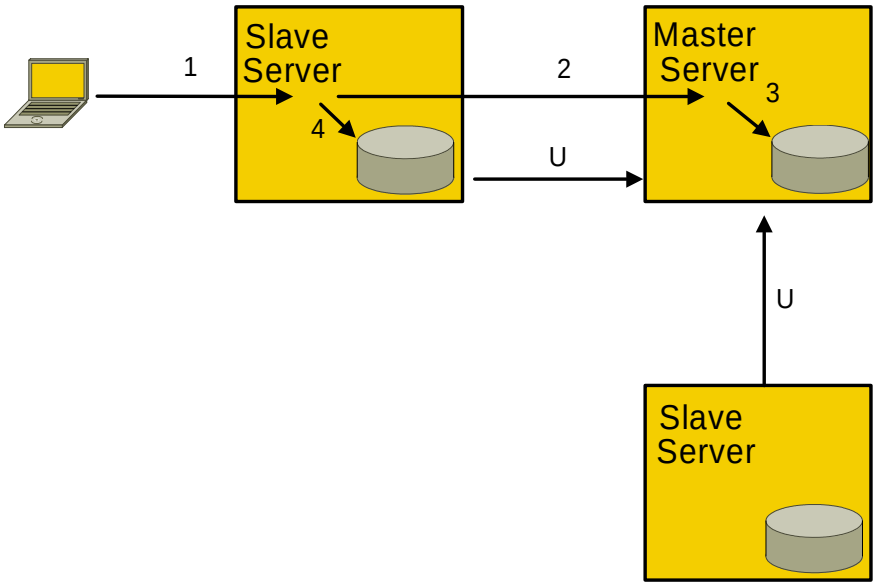


- **EGEE-II**
  - For a producer a register message now return the consumers of interest and vice versa.
  - Producers now notify consumers themselves
  - Messages to other servers go via a task on the task queue

Task Manager

- **Assumption is that tasks dependent upon some unreliable resource**
  - e.g. network connection to a server and that server
- **Assign a key to each resource**
- **One queue of tasks but a pool of task invocators**
- **Simplified algorithm:**
  - Initially empty set of good keys
  - If a task is successful on its first try its key is added to good set
  - If a task fails its key is removed from good set
  - Only if key is in good set will more than one task be run with that key
  - Some invocators only take tasks with a good key

Schema Replication



- **VDB is defined by a configuration file identifying the master server**
  - Tried to avoid a master but very difficult
- **Each server has full information for each VDB served**
- **Updates are first done on the master**
- **Replication request is "updates since"**

Registry replication

- **A registry "owns" those records that were last changed by direct calls and is responsible for pushing updates of these records.**
- **The registry is updated:**
  - by direct calls – sets master flag
  - upon receipt of replication messages – clear master flag
- **If registry unavailable direct update requests are routed to a different registry instance and records in the new registry will get the master flag set.**
  - The system will clean up when a registry assumes mastership for the record and replicates its records.
- **A hash table is used to hold the add registration and delete registration requests keyed on the primary key of the entry.**
  - Each replication cycle a new hash table is created to take new entries and the old one is processed.
- **Time stamps are associated with the replication messages**
  - Can recognise missed messages and recover

Conclusions

- **Try to think of everything that can go wrong.**
- **Keep it simple.**
- **Polling can be simpler though less efficient than notification.**
  - Don't have to deal with lost notifications
- **Make the system self correcting and avoid critical messages.**
- **Avoid single points of failure.**
- **Reject incoming requests if a server cannot cope rather than just going slowly or crashing.**
- **Server code should protect itself against running out of memory.**
- **External conditions can change at any time: it is not good enough to just check at service startup.**

This will give us a highly reliable and scalable R-GMA.