Unbound in C

San Diego - 2006

Wouter Wijngaards
(wouter@NLnetLabs.nl)

Outline

- **Goals**
- **Design**
  - Server design
  - Module design
- **Major Issues**
  - Threads
  - Local zone server
  - Compression
- **Detail Issues**
  - Data Store
  - Spoofing Prevention
  - Overload Handling

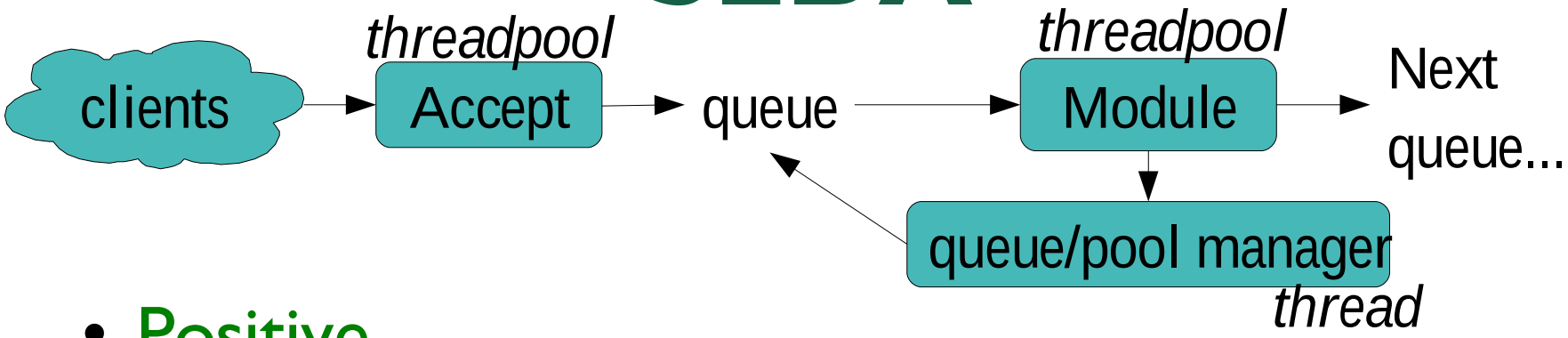
Goals

- Validating recursive DNS resolver
- Another alternative open source implementation
- DNSSEC, RFC compliant, high performance
- Elegant design
- Portable C
- BSD License(?)
- NOT
  - an authoritative server
  - Feature bloat – difficult for a resolver

Server design options

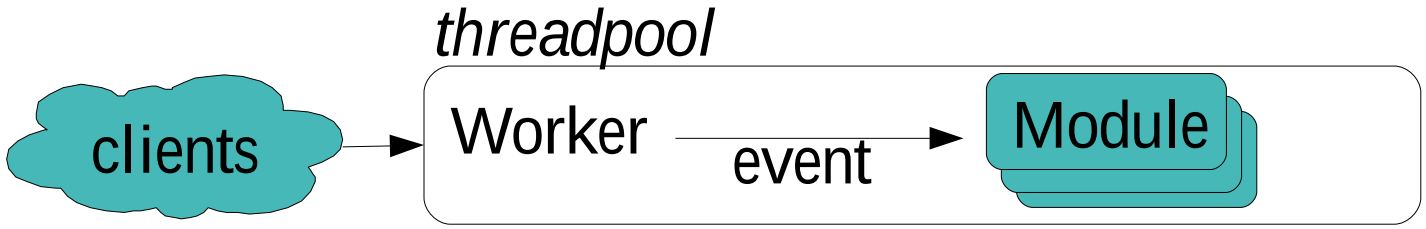
- How to thread and do the workflow?
  - Looked into literature
- Event driven
  - Select() and events drive state machines
  - Every thread has all modules
- SEDA
  - Staged event driven arch
  - Queues to threadpools that do one module
- Discussion of these two options on next slides

SEDA



- Positive
  - Queues reordered for cache
  - Unequal validation load could be moved
- Negative
  - Queues add enormous latency to requests
  - Queue and thread management problem
  - Slight downfall on DoS
  - Queue growth memory problem

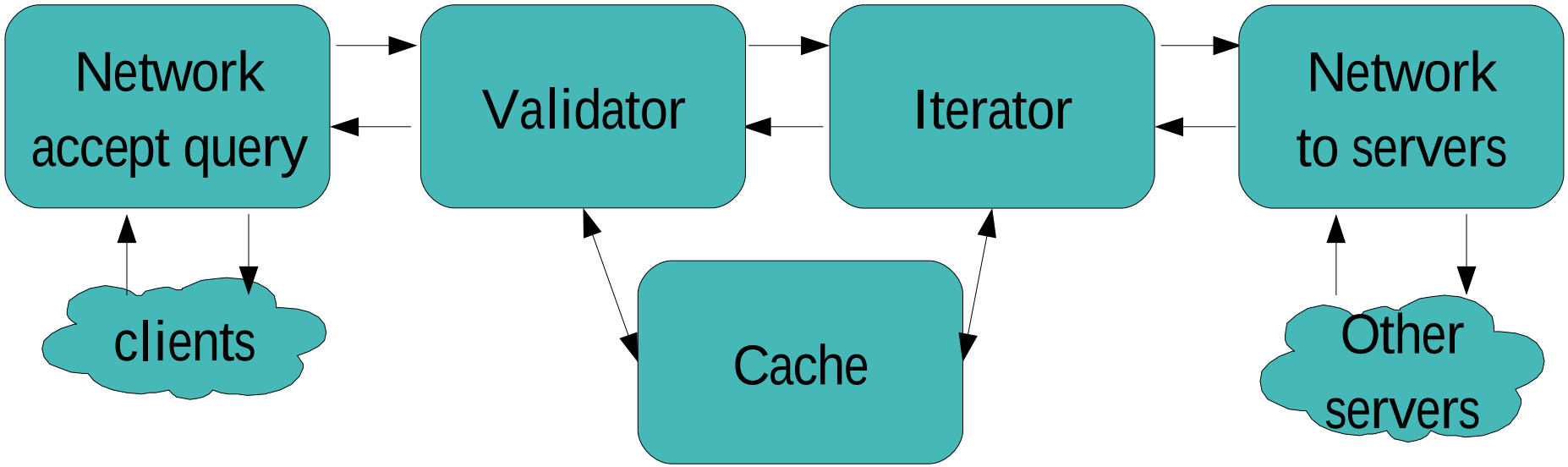
Event driven



- Main routine blocks in select() call
  - Every module has a state, event-driven
  - Process every request until finished or blocked.
- Positive
  - Good characteristics under heavy load
    - Requests are finished instead of queued up.
  - Less overhead in queuing, locks, thread scheduling
- Negative
  - Complicated due to stateful modules
  - Validation load falls to thread that accepted request

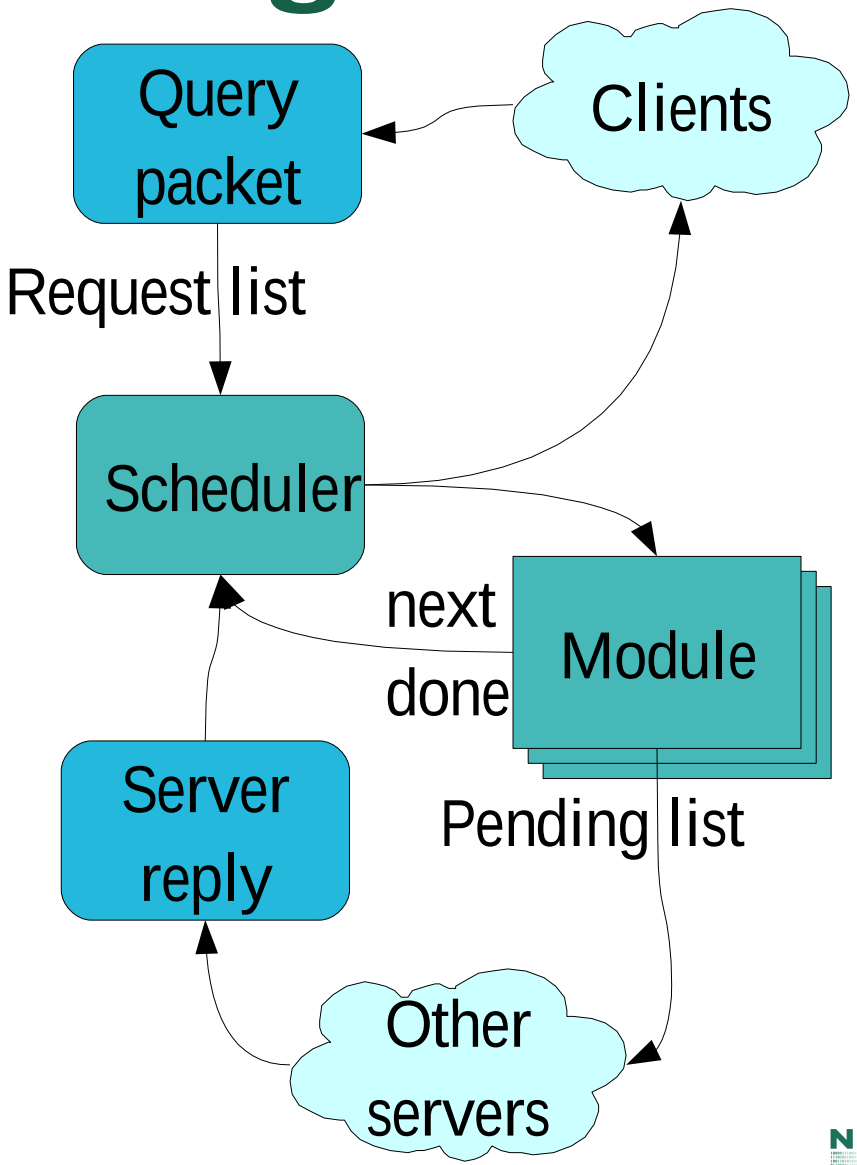
Workflow

- Clean modules can be used for any design
- Modules to call another – from Unbound Java

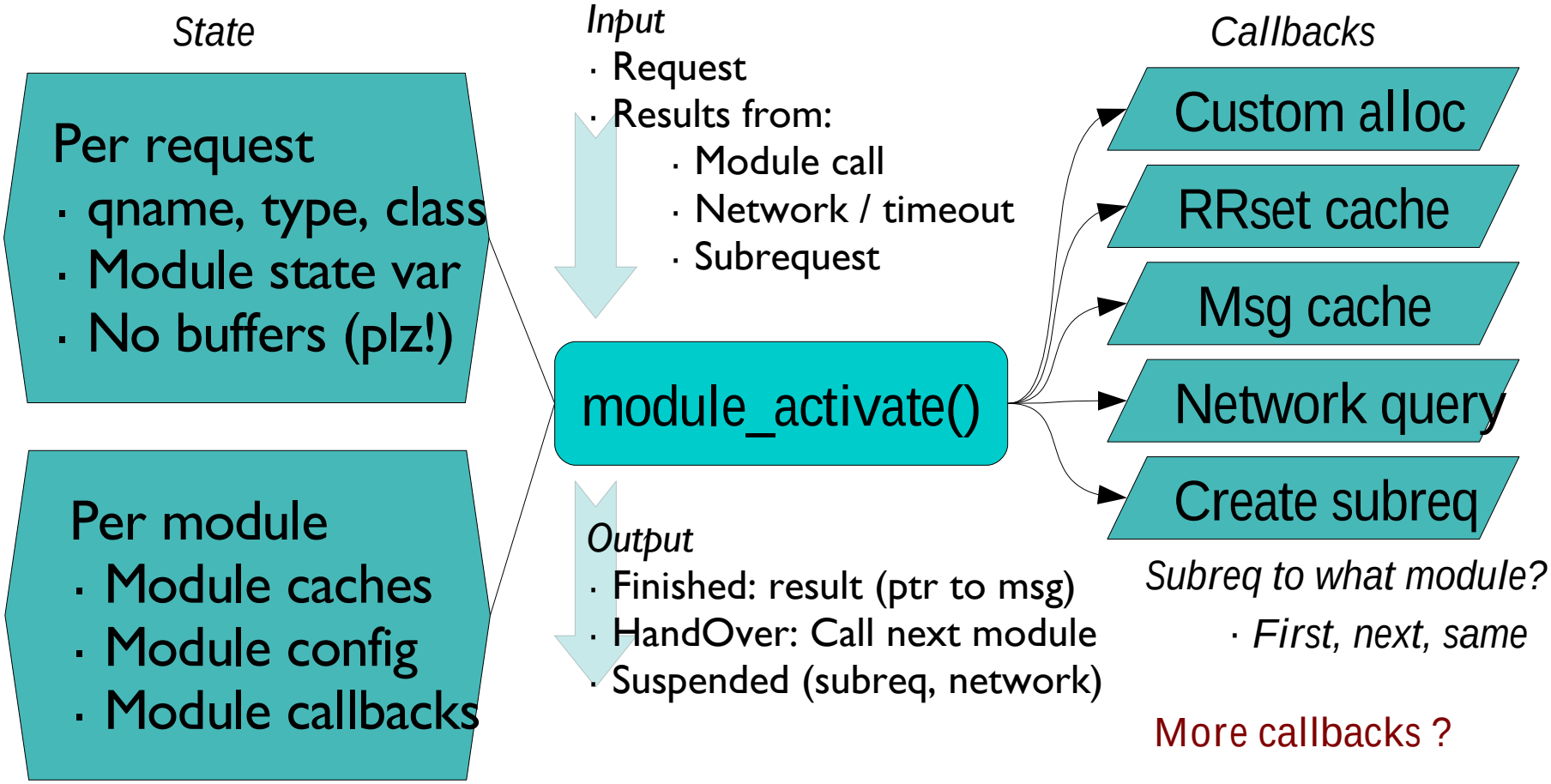


Server design

- Server main puts requests in queue
- Handler
  - Look in msg cache
  - Calls modules
  - Send reply if done
- Messages from network can wake up a suspended request



Module Design – input!

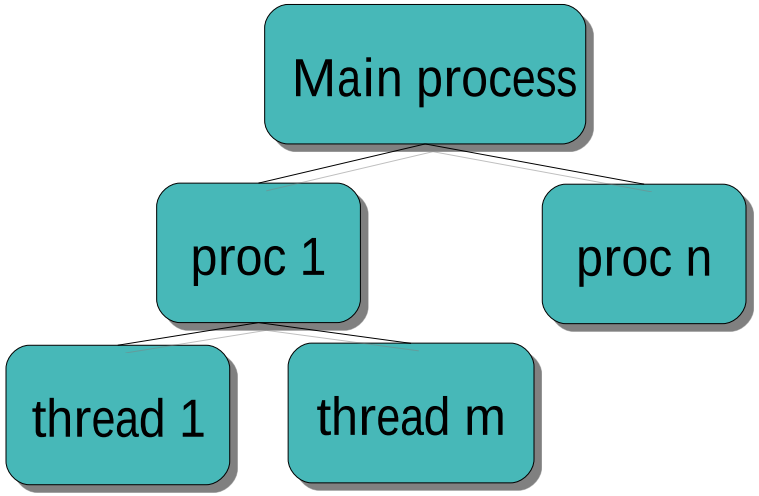


Link and Compile

- Every module can be linked on its own against a main program
- Main program provides callback services
- Different main programs to make
  - Unit test programs
  - Resolver library
  - Remote (TCP) module connections
  - Server
- Valid, iter are clean modules but cache is still special.

Threading and forks

- Threads
  - Speed advantage on shared memory cache
  - As little locks as possible
  - Work without threads too



- Every thread
  - Listens on port 53
  - Listens to own port(s)
  - Own query list
  - Own local cache (called L1)

- Shared - locked
  - shared cache (called L2)
  - Request counts
  - malloc/free service

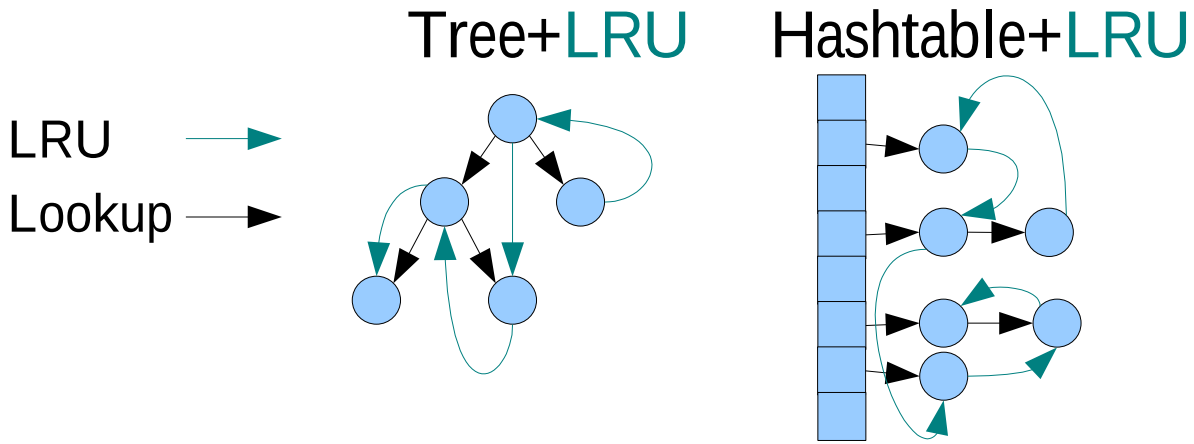
Caches – Need input!

- Caches
  - RRset
  - Msg-reply
  - Trusted-key
  - Infrastructure
- Where? L1(local), L2(shared).

- Clean cache design?
  - Generic L1-L2 fallback
  - Generic by datatype, module.
  - Some caches do
    - static config
    - Localzone serve

Local Cache

- L1: rbtree, hashtable.
  - LRU double linked list woven in, delete items to make room if at max size of the cache.
  - Timeout checked when access an item - refetch



Shared Caches

- L2: hashtable, locks per bucket.
  - Read: Copy data out – no locks per entry
  - LRU? Write/Delete? Avoid deadlock.
    - Separate double linked LRU list?
      - Find an item to delete – snip off LRU list. Then delete in hashtable (get lock on buckets).
    - LRU updated on reads – how locking?
      - Unlock bucket, get lock on entire LRU list to update.
    - One big lock on LRU list. Bad. (input!)

Local zone server

- Need a local zone served (.localdomain)
- AS112 zones, do not leak
- Unbound not authoritative server!
- Options
  - NXDOMAIN (default for AS112)
  - Forward to (NSD) on host:port
  - Basic service
    - No CNAME, DNAME, wildcards, NSEC ...
    - This is authoritative service!
      - Do it right or don't.

Compression

- Never uncompress incoming data:
  - Hard to store RRsets separately
- sendmsg/writev gather of uncompressed data
  - Use header,qname and rrset data without copying (!)
  - Have to update TTL values before send
  - Canonical rrset format ready for validation crypto
- copy&compress: use rbtree in L1 rrset cache for offsets
  - As a config option; copy=less cpu, compress=less bytes.
- Keep Rrsets locally compressed
  - Have to update compression ptrs and TTLs before send
  - Not canonical format
  - Imperfect compression ratio

Data store

- Packed RRset
  - Keeps wireformat RRset, ptrs to RRs, TTL.
  - Could keep RRSIG over the RRset as well
- TTL in absolute times
  - Use min TTL for RRsets, messages.
- Cache entries have validation status
- Store hashvalue in cache objects.
- dnames kept in wireformat, label offsets
- Ldns: No need to do all DNS constants again

Msg-RRset pointers

- Msg(q+reply) consists of RRsets
  - Keeping RRset inside msg is waste memory
  - Rrset*: hard to find/lock msg on rrset delete
- First 64bits in RRset are creation ID.
  - thread_num (16bit), seq_number (48bit).
  - seq_number wraps: clear cache / abort
  - Keep RRset* and ID, check ID on use.
- Reuse RRset memory only for RRsets
  - Zero ID means RRset is not in use.
  - Copy RRset from/to cache gets new ID.

Spoof Prevention

- Random IDs:
  - Random() with initstate(256 bytes)
- port ranges:
  - Needed per thread (to listen easily)
  - Kqueue, kpoll() sys calls
- Scrubber for incoming messages
  - Routine in Iterator? Or Validator?
  - Spoofed NS additionals confuse iterator
    - But get caught by validator afterwards
  - Scrubber as a module?
    - Between iterator and network.

Overload handling

- On overload answer from cache
- Detect overload
  - Request list is full
  - One thread: stop listen port 53
  - All threads: overload mode
    - Answer from cache or drop query.
- Schedule 1:2 ratio for port 53 : other ports
  - Does not depend on number of other ports
  - Drives towards completion of waiting queries
  - Every select: perform 0/1 port 53 and round robin the other ports handle at most 2.

Concept Module: Remote Cache module

A remote server

- Runs with a cache module only
- Store/Retrieve msg and reply
- Like remote msg cache
  - Localhost cache for nonthreaded pcs
  - For a resolver farm

Cache module

- Checks msg cache
- If not: network msg to cache server (suspend)
- If not: next module
- Result next module
  - Store on server
  - Finished(result).

Summary

- Event driven
- Modular design
  - Callbacks – minimal OO
  - Modules can call next module
  - Suspend waiting for network reply
- Threads: minimal, cache a copy
- Needs tweaks
  - Compression choice
  - Cache code
  - Module interfacing

Unbound-C

Family of *Unbound-Java*