Emerging Communication Patterns in Actor Systems

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Agenda

Fallacies of Distributed Computing

New developers often have a set of assumptions (L. P. Deutsch):

- The network is reliable
- Latency is zero
- Bandwidth is infinite
- The network is secure
- Topology doesn't change
- There is one administrator
- Transport cost is zero
- The network is homogeneous

These assumptions ultimately prove false, leading to performance issues and system failure.

Fallacies of Actor Programming

Some of Deutsch's fallacies also apply to actor programming:

- Latency is zero
- Bandwidth is infinite
- Topology doesn't change
- There is one administrator
- Transport cost is zero

More Actor Fallacies

There are also new ones:

- Unbound mailboxes means infinite space
- The runtime is intelligent

The Truth about Message Passing

All messages go through ...

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All messages go through ...

... the river of slime

The Slime

- Actors drop messages into the slime
- Other actors eventually take it out
- The slime is not intelligent
- The slime fights back if you overload it

Angering the Slime

How to anger the slime:

- Send large messages to compute very little
- Add many, many buffers by building complex topologies
- Send messages faster than they are consumed

If you do any of this, the slime will slow you down or even kill you.

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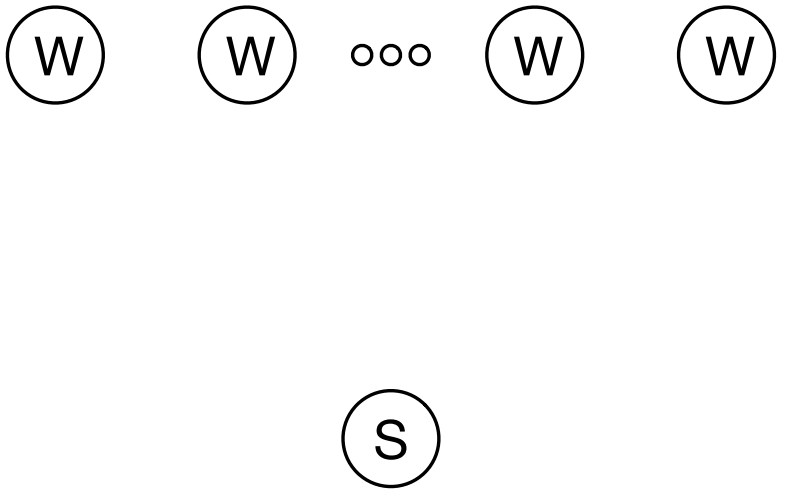
Causes for Overloads

Different communication patterns cause different overload scenarios

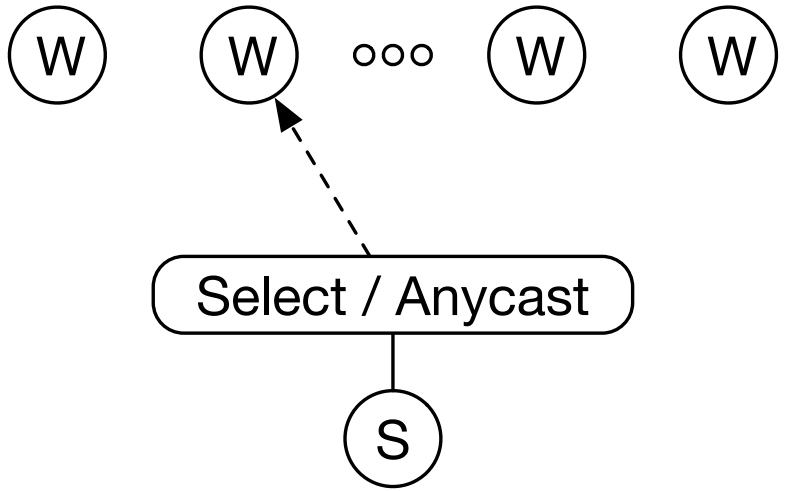
- External systems send too many requests, all nodes overloaded
- Single dispatcher (1:N) acts as bottleneck, others under-utilized
- Dispatcher (1:N) has no feedback channel, all workers overloaded
- (Accidental) N:1 message flows shuts down a single node

1:N Patterns



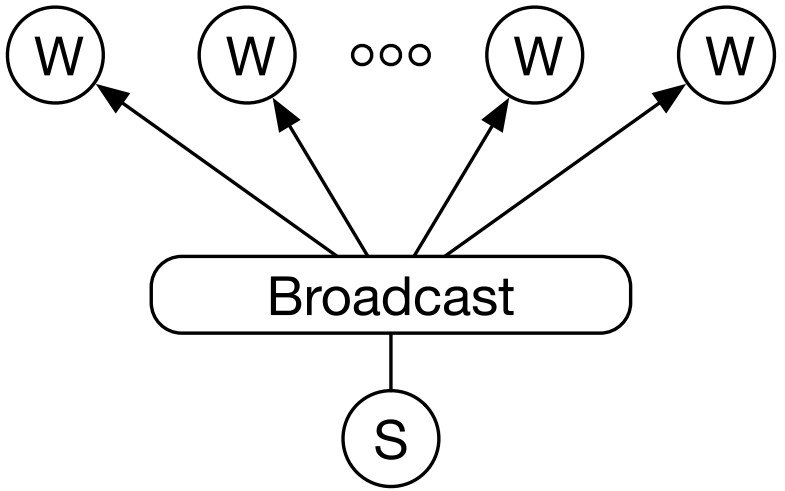
- 1 Supervisor (S)
- N Workers (W)

Select Single Worker



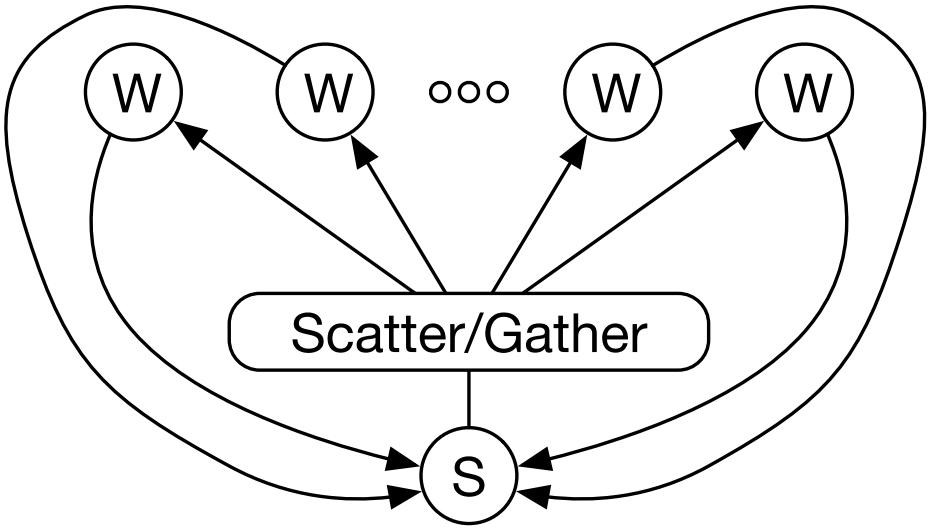
- Supervisor delegates single work items
- Strategy is critical (round-robin, shortest mailbox, ...)

Broadcast



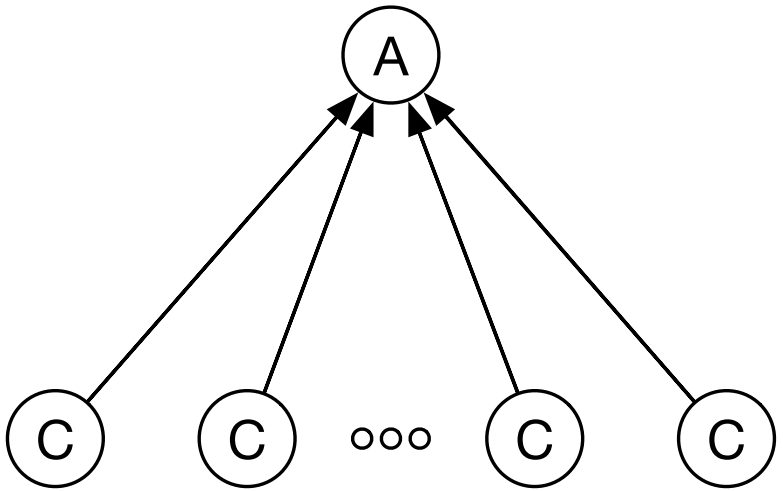
- Supervisor multiplies work items
- Fair scheduling among workers required

Scatter/Gather



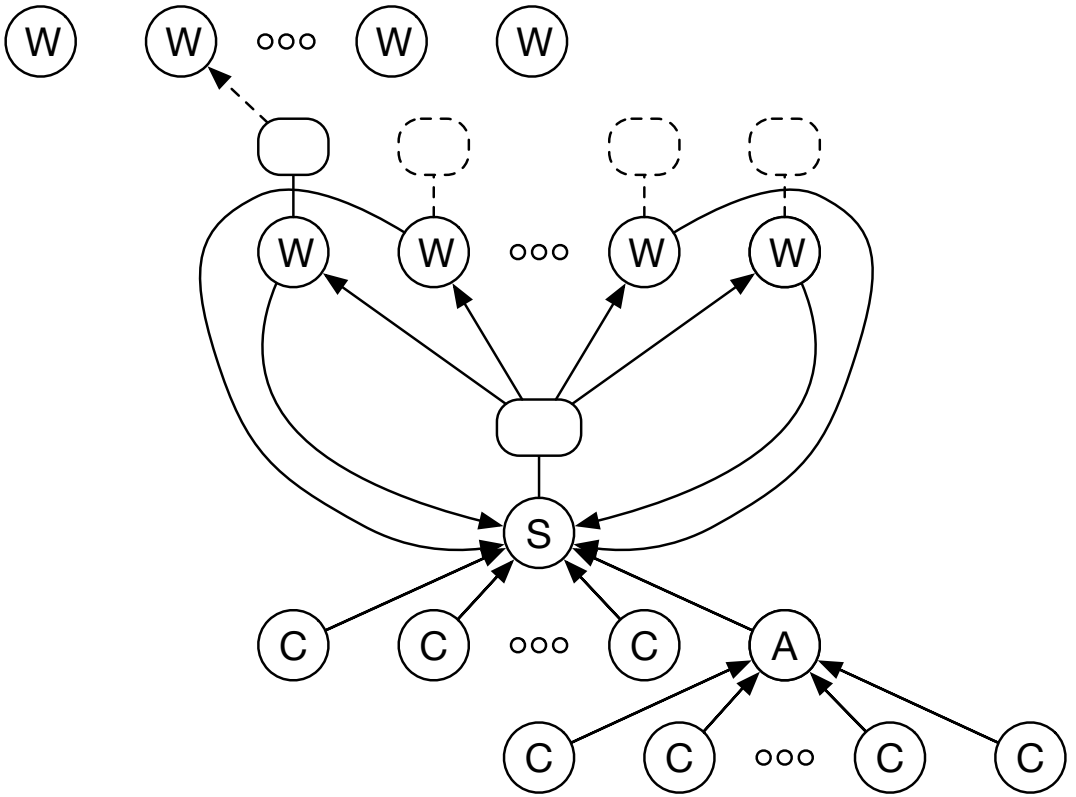
- Supervisor multiplies work items & collects/combines results
- Same as broadcast + heavy load on Supervisor

N:1 Patterns



- Single actor (A) offering a service
- N clients (C) using it

N:M Compositions



- Real-world systems are compositions of several patterns
- Complex service hierarchies, patterns emerge during development

Load Management

- Actors must manage the flow of messages
- Actors in critical path must be “defended” against overload
- Feedback channel between receiver and sender(s) needed
- Senders must adopt to consumption rate

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Preliminary Considerations

- Messaging layer cannot “stop” actors from sending (too much)
- Slime is not intelligent, actors are (should be)
- Latency cannot be foreseen or precalculated, only observed
- Bursts must not stop the system from running
- Silently dropping messages not an option
  - Errors have to be explicit
  - Dropping messages *is* a valid strategy, if observable

Goals

- Make emerged communication patterns explicit
  - Traceable interaction between identifiable subsystems
  - Ease reasoning about software architecture

- Provide high-level software building blocks
  - "Standardized" message types for composable interfaces
  - Simple setup for common patterns, configurable and tunable

Architecture Design Space

- "Bottom-Up": Build each subsystem individually as black box
  - Hides service hierarchies
  - No inter-component dependencies
  - But: overhead (load management) between all components

- "Top-Down": Build topology for large (sub-) system
  - Service hierarchies explicitly modeled
  - Load management only once at each critical path
  - But: (potentially) high complexity

Load Management

- Do as much work as possible, but not more
- Buffers can become harmful: system should stay responsive
- Reject task as soon as possible, before committing resources
- Once task is accepted, complete as early as possible
- Give clients clear indication why task has been rejected
  - User might try again later (temporary burst)
  - Allow non-interactive client to slow down or propagate error

Management Strategies

- Token Bucket
  - Each task consumes a token
  - One token per worker + buffer for small bursts
  - Finished tasks release token
  - Reject task if no token is left
- Rate Limit
  - Allow only X tasks/second
  - Based on engineered capacity or adaptive
- Wait queue with limited sojourn time
  - Sojourn time: time between enqueue & dequeue
  - Restrict time elements are allowed to stay in queue
  - Reject task if no worker became available in due time
  - Defines worst case latency

Load Management Design Space

- Static vs. dynamic setup (templated vs. virtual dispatching)
  - Templated code makes algorithm choice explicit
  - Virtual dispatching allows for runtime configuration
- Feedback loop design (negative vs. positive)
  - Small buffer at worker can minimize idle time
  - No buffer at worker avoids delaying tasks unnecessarily
- Buffer sizes and adaption rates
  - Balance between additional latency and short burst smoothening
  - Configurable rates require good guidance for users

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Erlang: “Jobs” Load Regulation Framework

- Regulation at the edges
- Highly configurable load management framework
- Protects core nodes from overloads by rejecting excessive work
- Inter-node feedbacks, pluggable queues, etc.
- Subsystem as black box

Akka: Routers

- Route incoming messages to outbound actors
- Several predefined strategies:
  - RoundRobinRoutingLogic
  - RandomRoutingLogic
  - SmallestMailboxRoutingLogic
  - BroadcastRoutingLogic
  - ScatterGatherFirstCompletedRoutingLogic
  - ConsistentHashingRoutingLogic
- Serve as building block for load management

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1. Fallacies of Actor Messaging
2. Overload Scenarios & Communication Patterns
3. Goals & Design Space
4. Example Frameworks
5. Conclusion

Conclusion

- Communication patterns should be explicitly designed
- Understanding message flow is crucial for performance
- Ideal position of load managers depends on patterns

Thank you for your attention!

Feedback and ideas?