Practical Messaging

A 101 guide to messaging

Ian Cooper

X and Hachyderm: ICooper

Who are you?

I am a polyglot coding architect with over 20 years of experience delivering solutions in government, healthcare, and finance and ecommerce. During that time I have worked for the DTI, Reuters, Sungard, Misys, Beazley, Huddle and Just Eat Takeaway delivering everything from bespoke enterprise solutions, 'shrink-wrapped' products for thousands of customers, to SaaS applications for hundreds of thousands of customers.

I am an experienced systems architect with a strong knowledge of OO, TDD/BDD, DDD, EDA, CQRS/ES, REST, Messaging, Design Patterns, Architectural Styles, ATAM, and Agile Engineering Practices

I am frequent contributor to OSS, and I am the owner of: https://github.com/BrighterCommand. I speak regularly at user groups and conferences around the world on architecture and software craftsmanship. I run public workshops teaching messaging, event-driven and reactive architectures.

I have a strong background in C#. I spent years in the C++ trenches. I dabble in Go, Java, JavaScript and Python.

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Day One Messaging

- Distribution
- Integration Styles
- Messaging Patterns
- Queues and Streams
- Managing Asynchronous Architectures

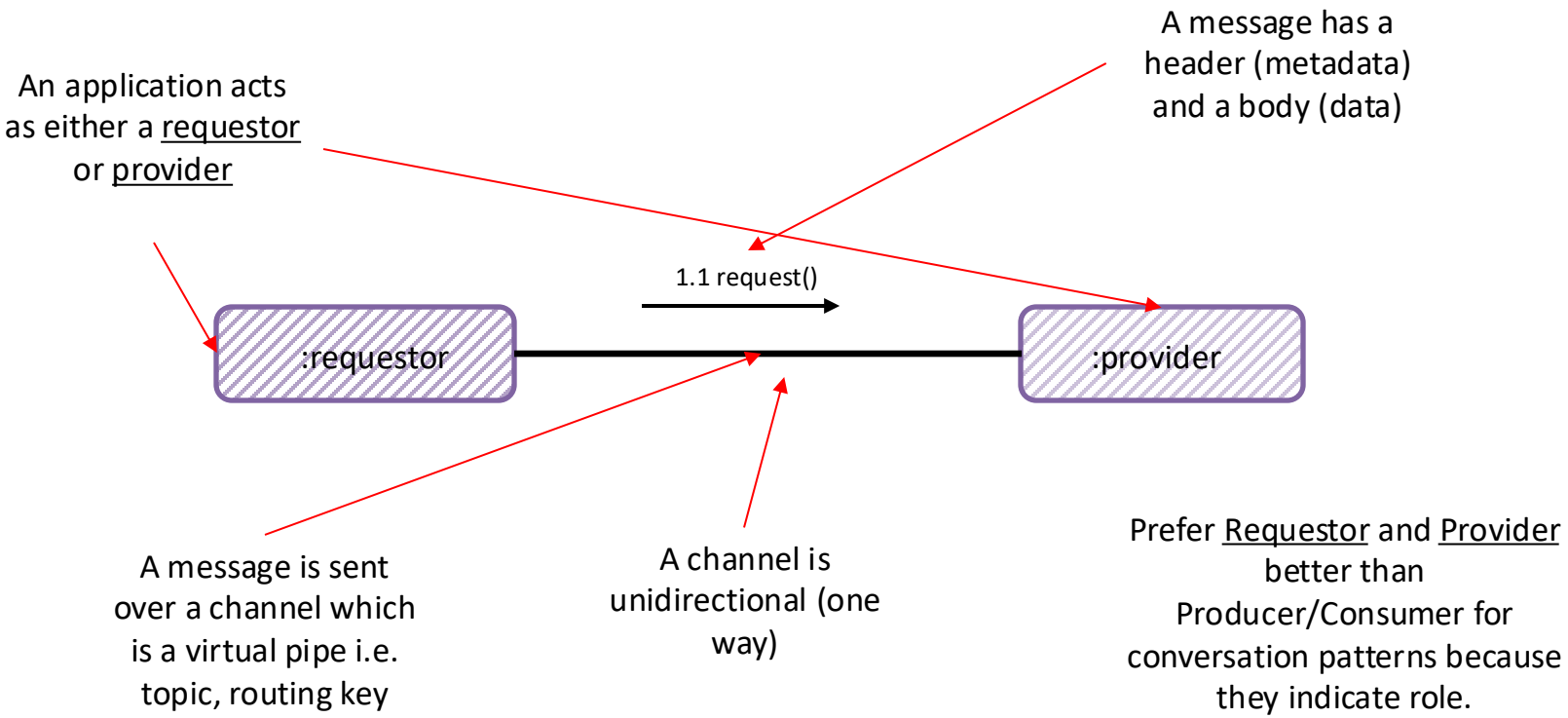
Day Two Conversations

- Conversation Patterns
  - Activity and Correlation
  - Repair and Clarification
  - Reliable Messaging
  - Fat and Skinny
  - Conversations
- Reactive Architectures
  - Message Passing
  - Paper Based Flows
  - Flow Based Programming
- Next Steps

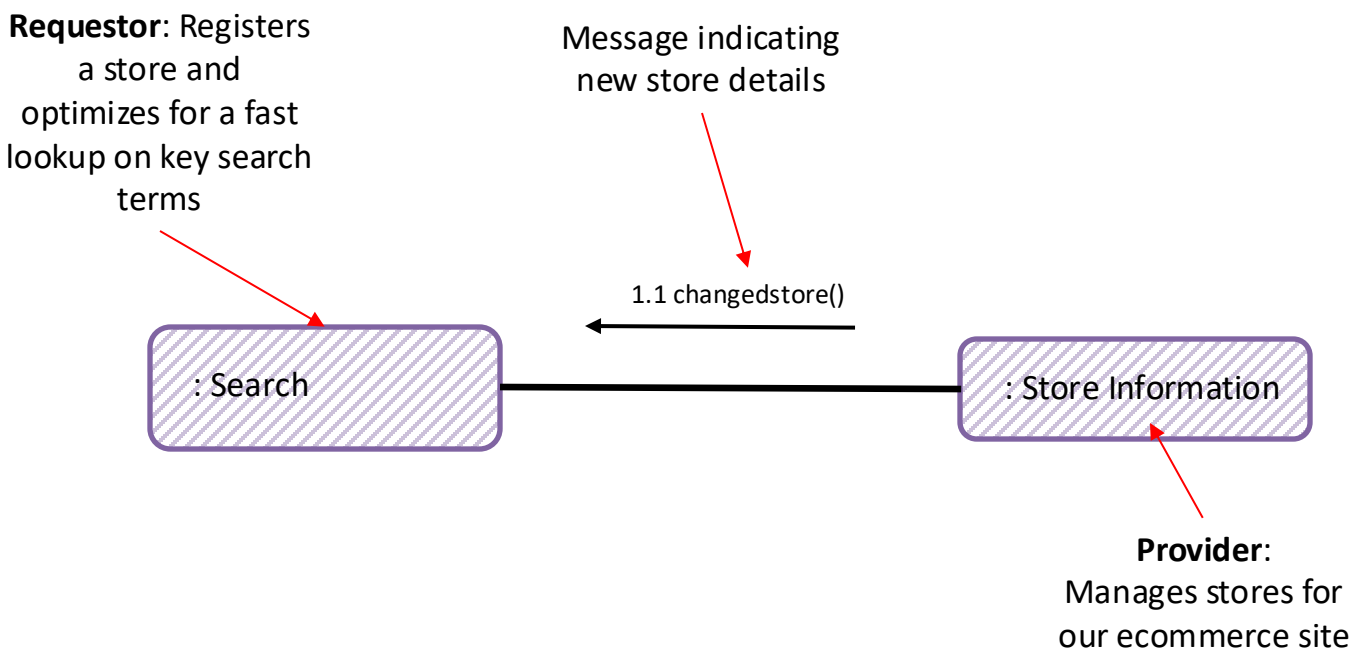
Day Two

CONVERSATION PATTERNS

Messaging Participants



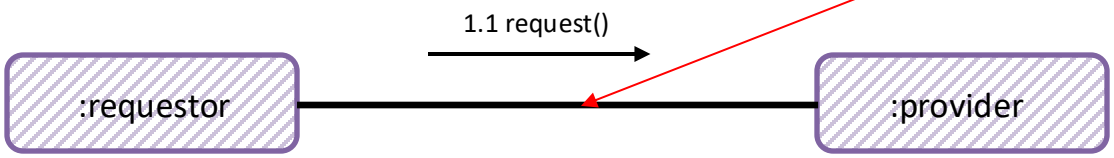
Messaging Participants



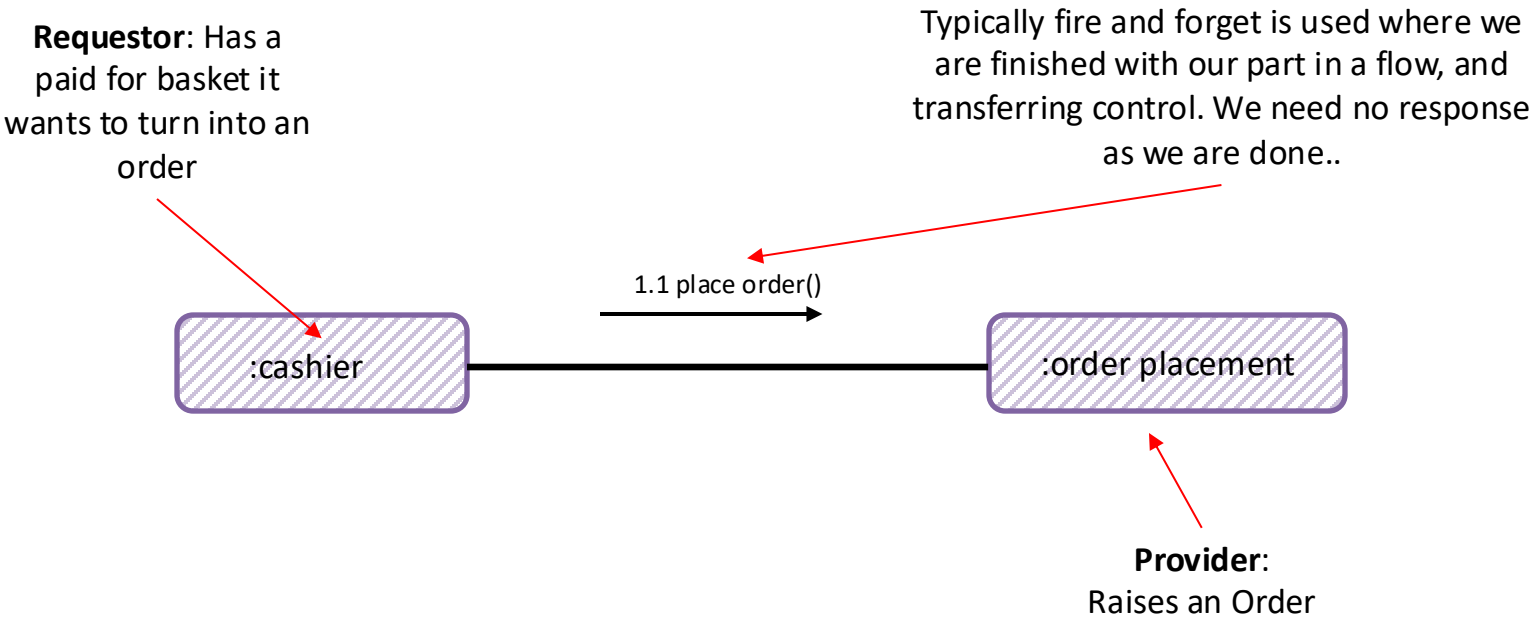
In-Only (Fire and Forget)

Typically we call this **fire-and-forget**.

Under a In-Only pattern the requestor sends a request to the provider, but does not seek an acknowledgment of completion of the requested operation



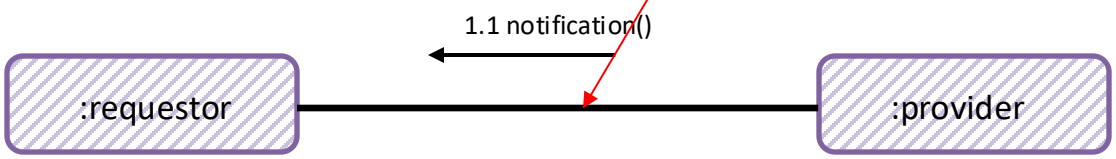
In-Only (Fire and Forget)



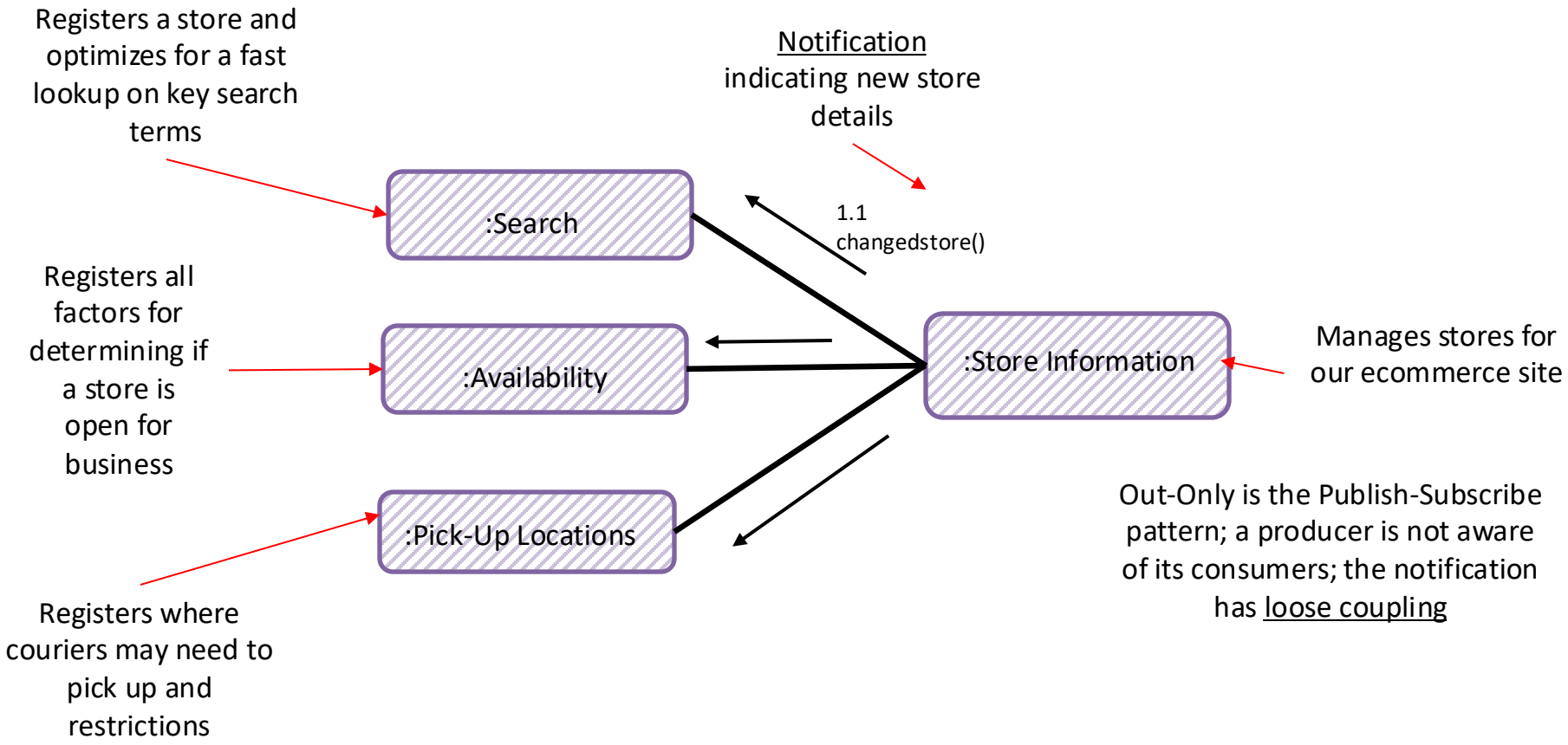
Out-Only (Notification)

Typically we call this a **notification**.

Under an Out-Only pattern the requestor subscribes to the provider, and an operation is triggered by receipt of a message but it does not acknowledge the message to the provider.

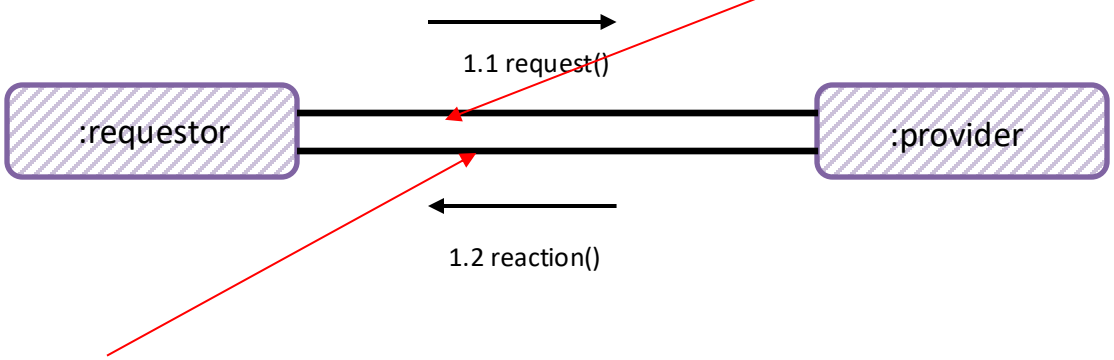


Out-Only (Publish-Subscribe)



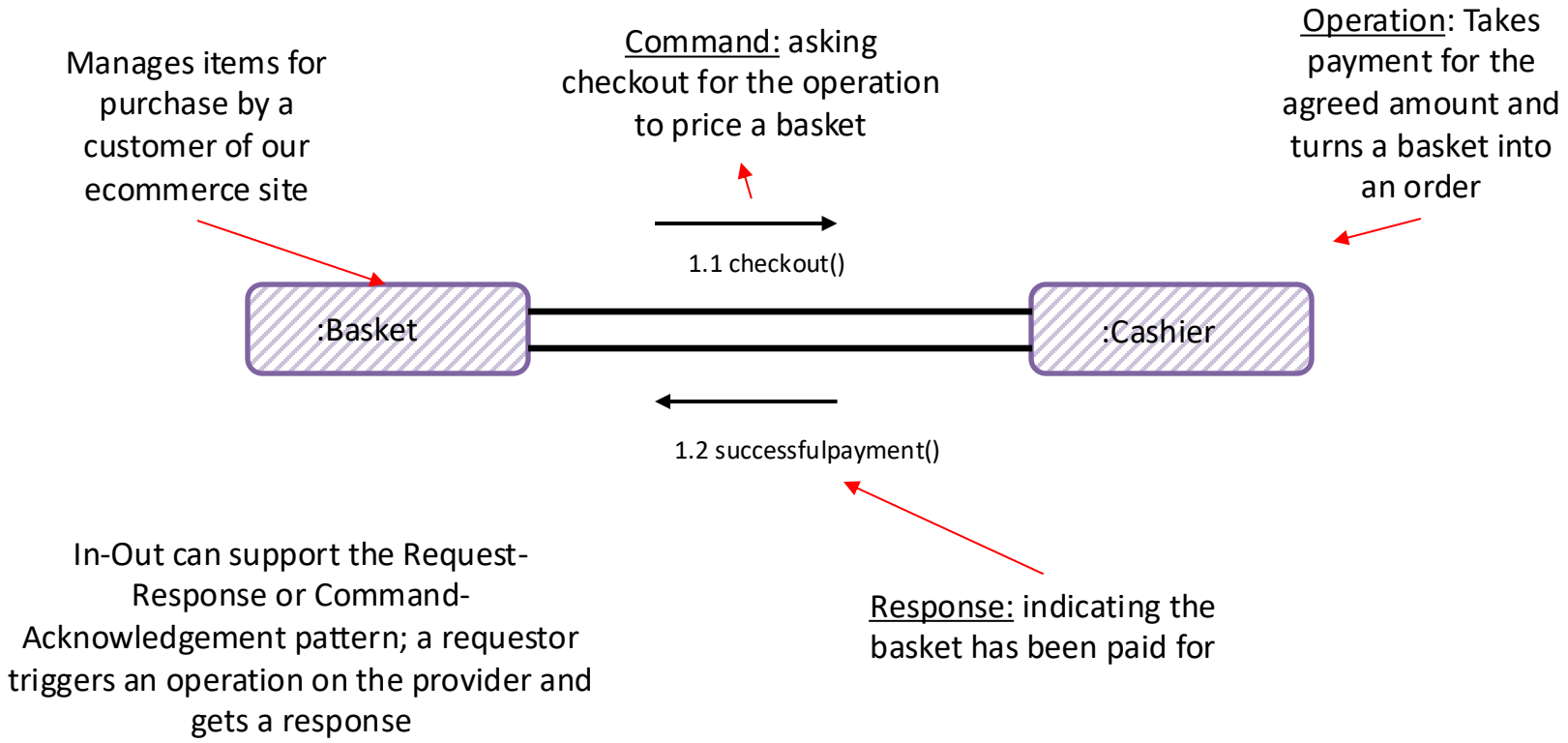
In-Out (Request-Reaction)

Under an In-Out pattern the provider receives a request from the requestor on one channel, and returns a response from the operation triggered by that message on a separate channel.

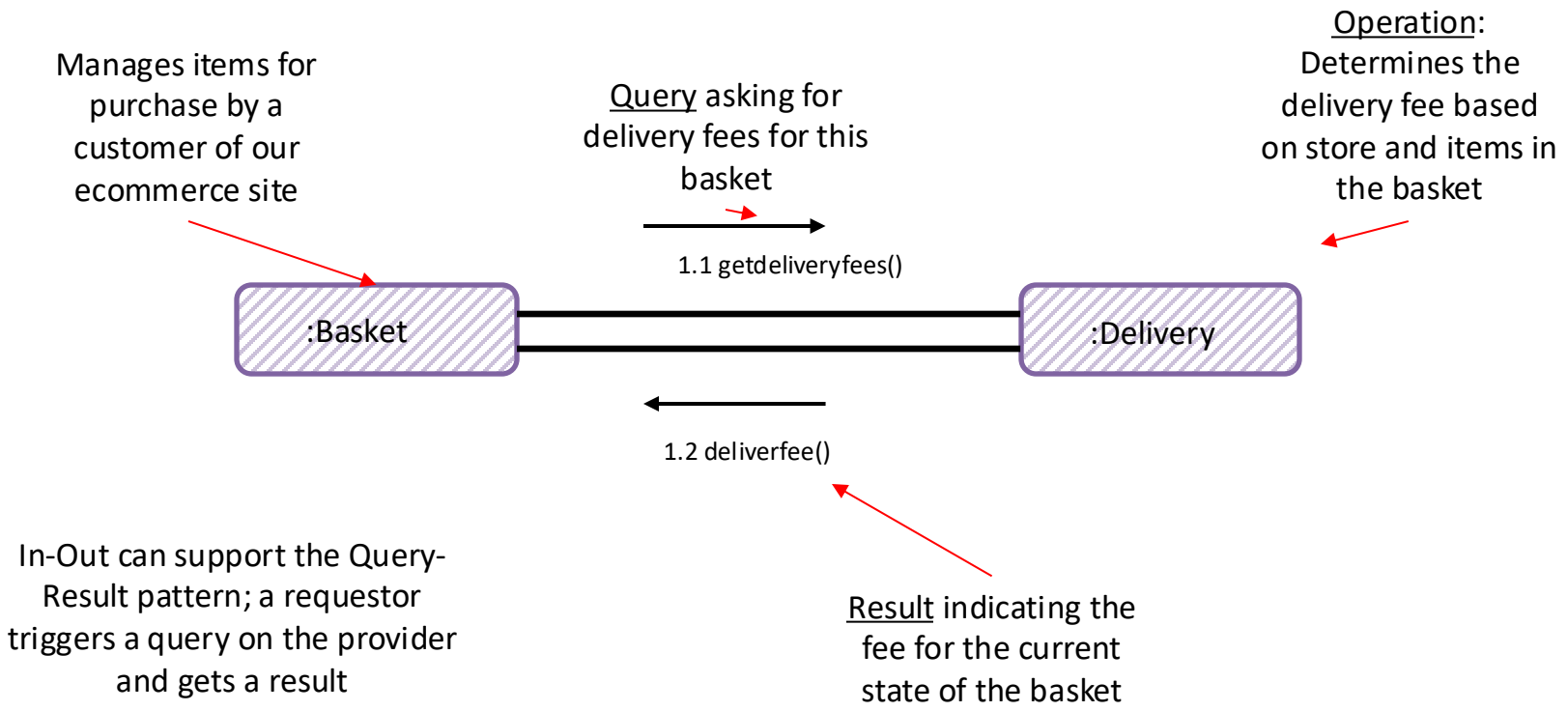


When using an In-Out pattern the provider sets a **correlation id** (conversation id) in the header of the request and the provider returns that id in the header of the response so that we can correlate replies sent over a separate channel.

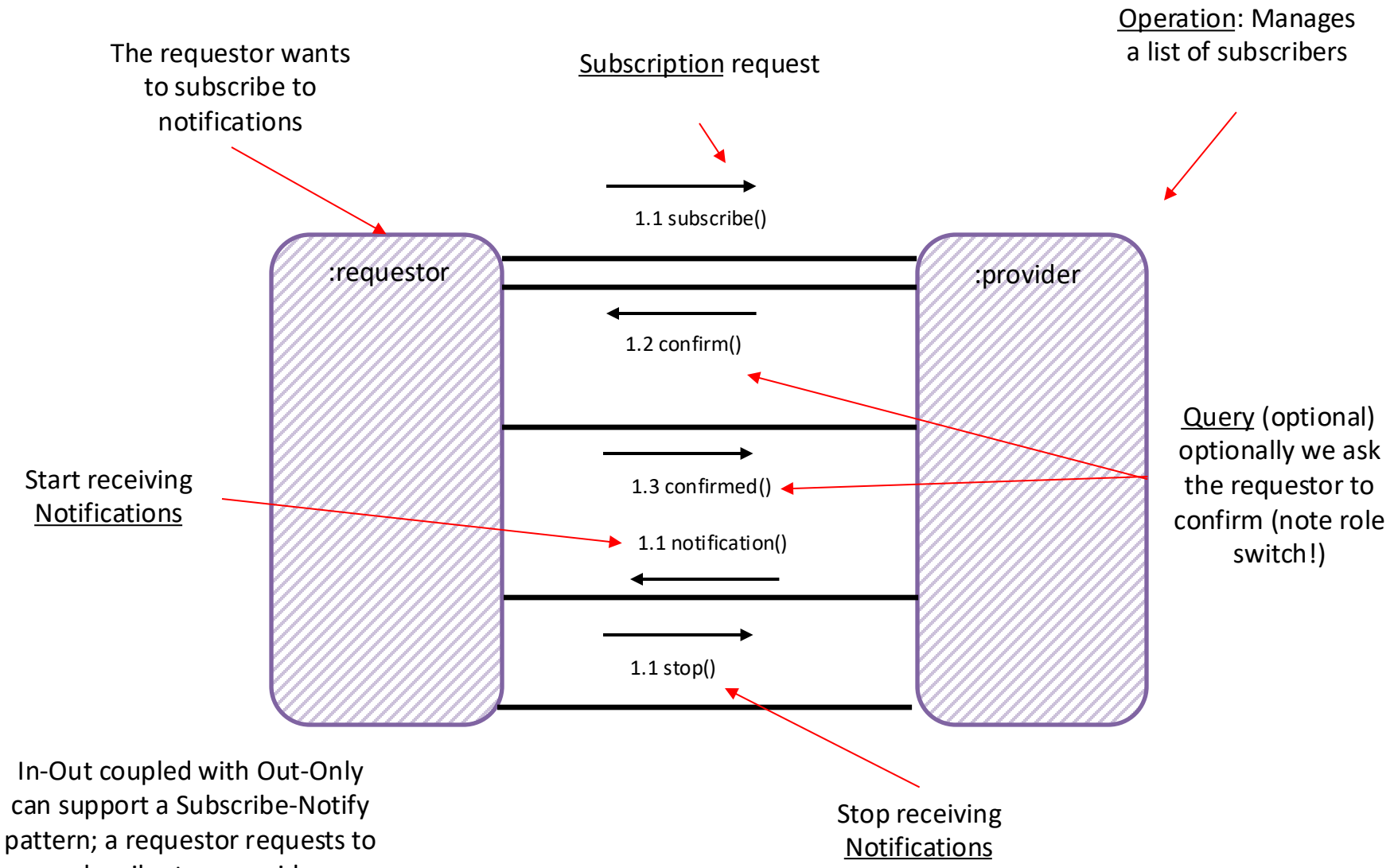
Request-Reaction (Command-Acknowledgement)



In-Out (Query-Result)



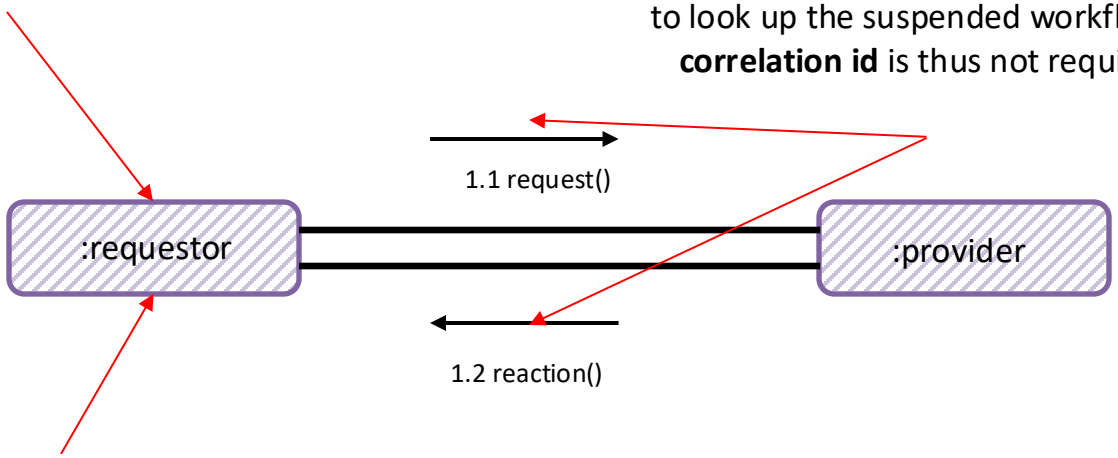
In-Out (Subscribe-Notify)



Blocking In-Out (Request-Reply)

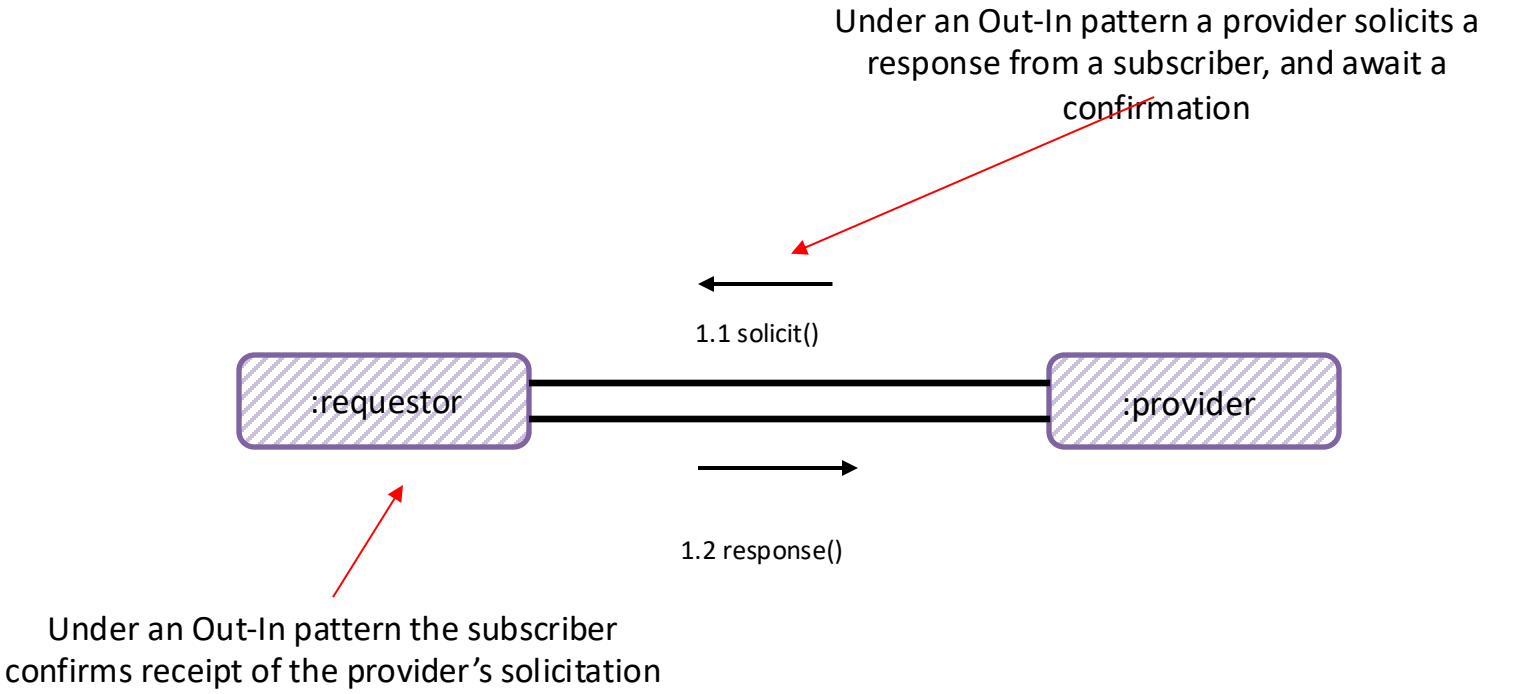
In order to resume, we need a way to identify the suspended workflow.

The requestor provides a unique **Reply To** channel (in the request message header/metadata) and the provider uses that channel for the response, allowing the sender to look up the suspended workflow. A **correlation id** is thus not required

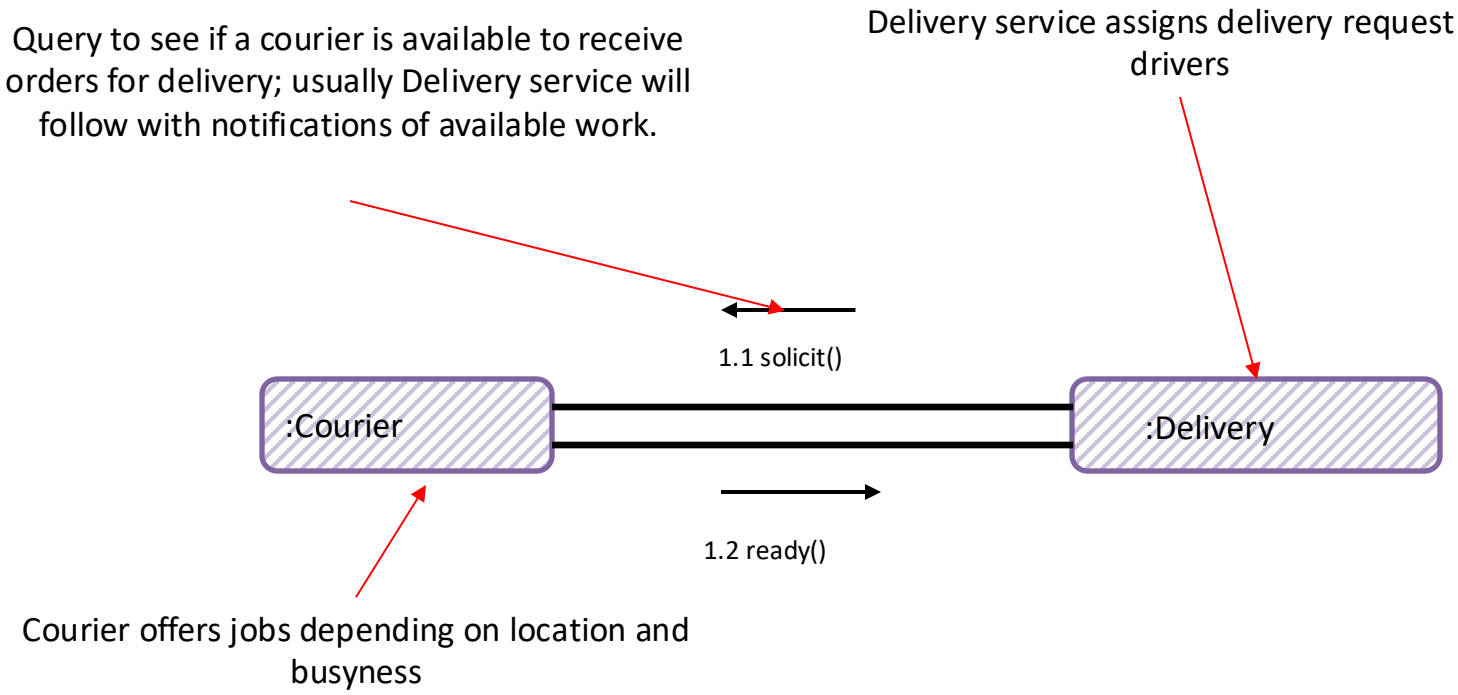


The requestor may block on the Reply To channel whilst awaiting the reply.

Out-In (Solicit-Response)



Out-In (Solicit-Response)



Messaging

Has Intent

Request An Answer (Query)

Transfer of Control

(Command)

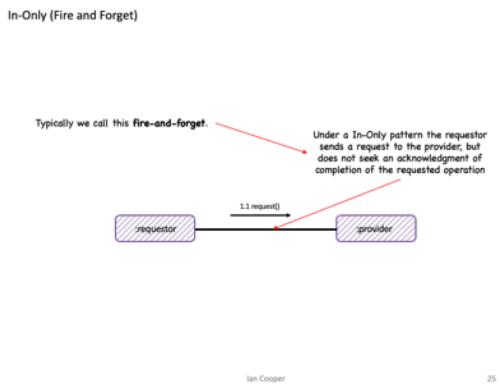
Transfer of Value

Part of a Workflow

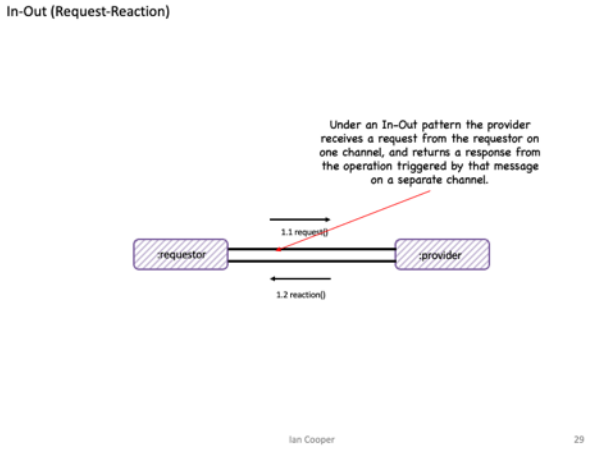
Part of a Conversation

Concerned with the Future

In-Only (fire and forget)



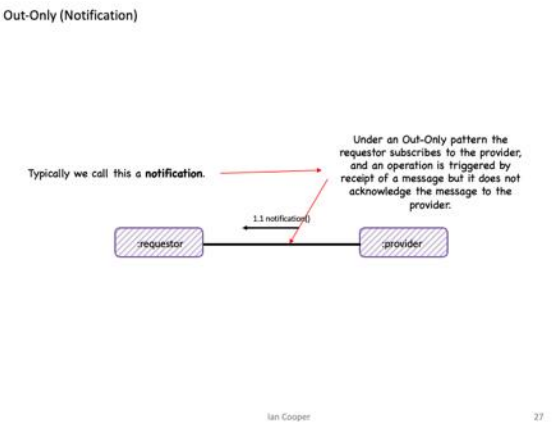
In-Out (request-reaction)



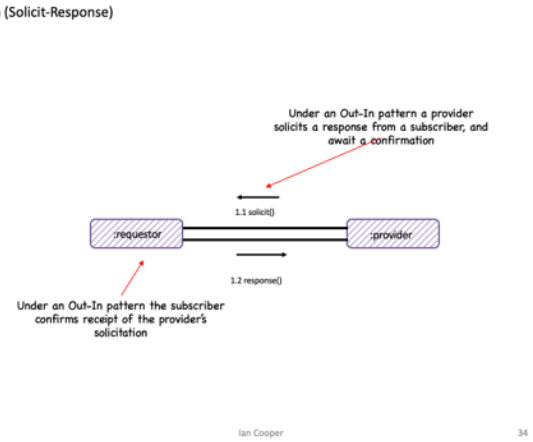
Eventing

- Provides Facts
- Things you Report On
- No Expectations
- History
- Context
- Concerned with the Past

Out-Only (notification)



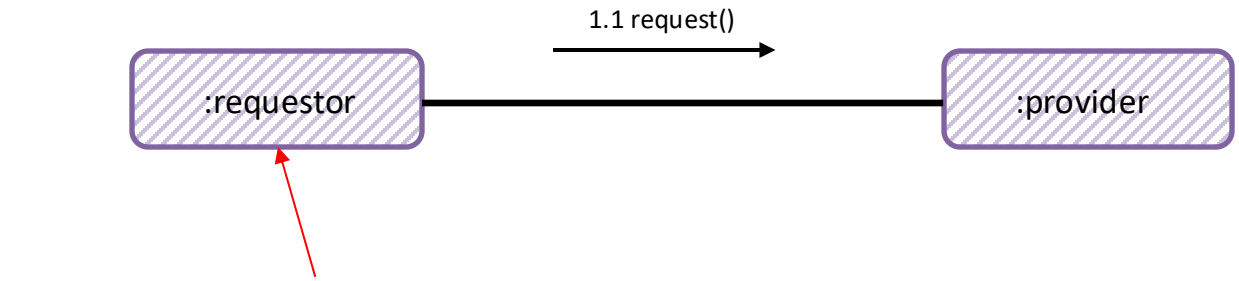
Out-In (solicit-response)



How do we manage workflows in requestors and providers

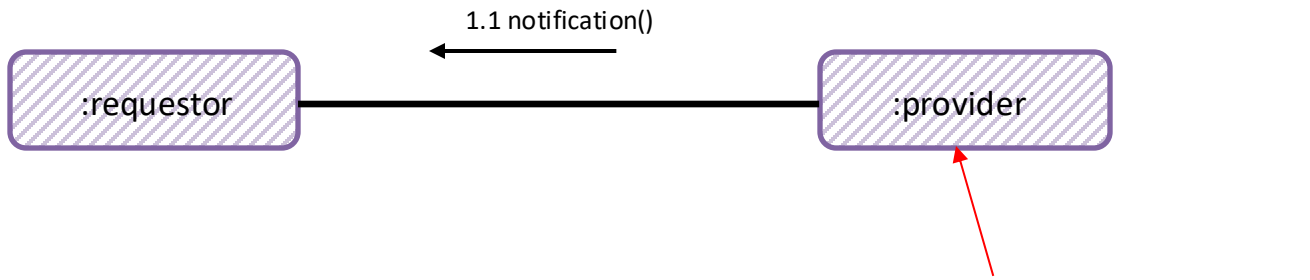
ACTIVITY AND RESOURCES

In-Only (Fire and Forget)



Because we are **fire-and-forget** there is no need to maintain state to correlate with a response; we don't expect a response

Out-Only (Notification)

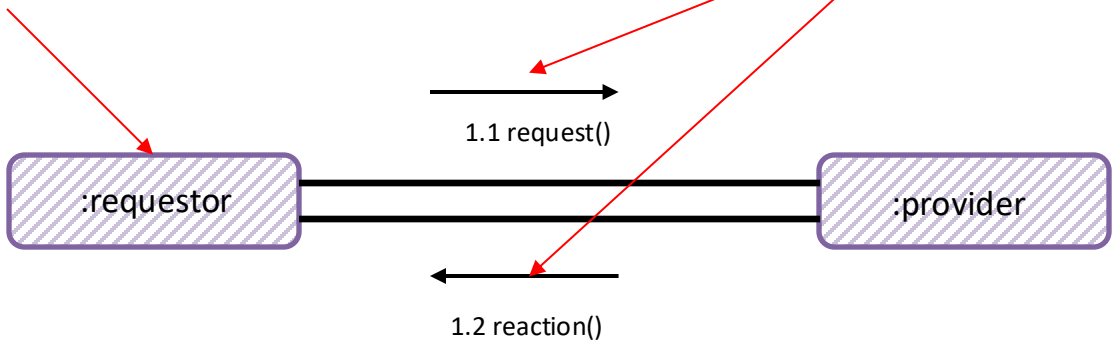


Because we only **notify** there is no need to maintain state to correlate with a response; we don't expect an acknowledgement

In-Out (Request-Reaction)

We may resume a workflow that we suspended, whilst we were waiting for a response

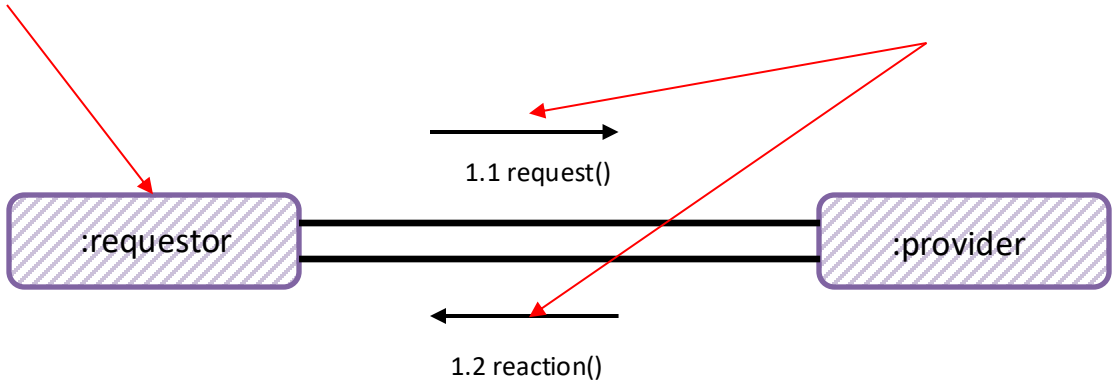
Because we expect a response to our request we may need to save state which we then correlate with the request



In-Out (Request-Reaction) Correlation Id

In order to resume, we need a way to identify the suspended workflow.

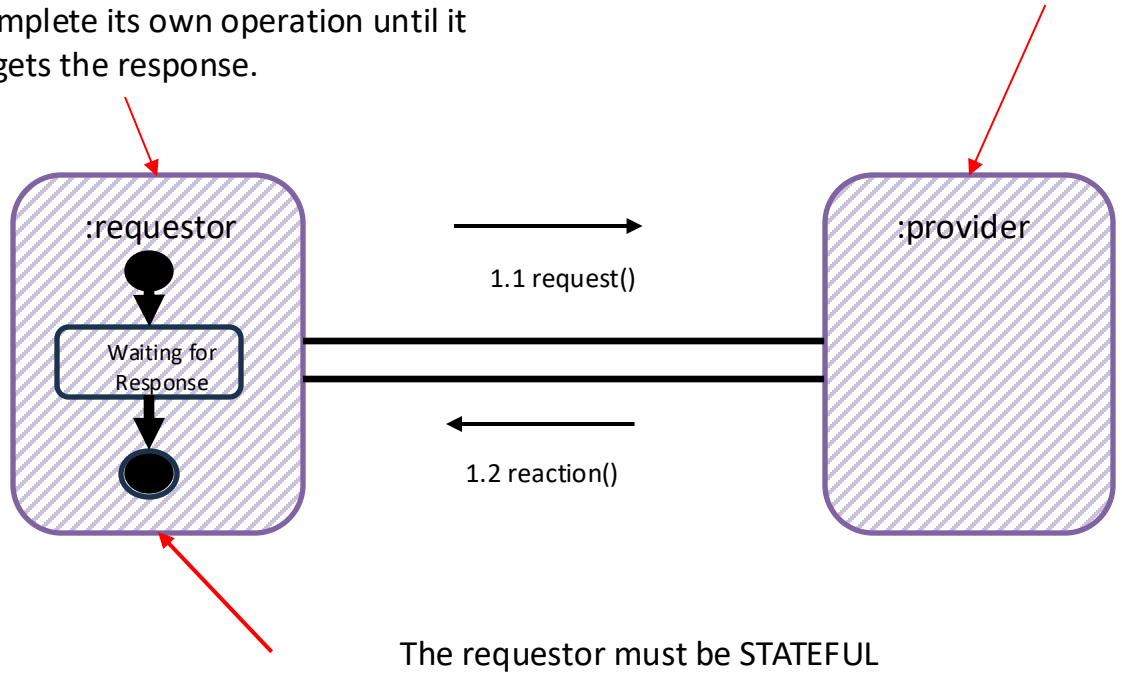
The requestor adds a **Correlation Id** (in the request message header/metadata) and the provider returns that in the response, allowing the sender to look up the suspended workflow



In-Out (Request-Reaction)

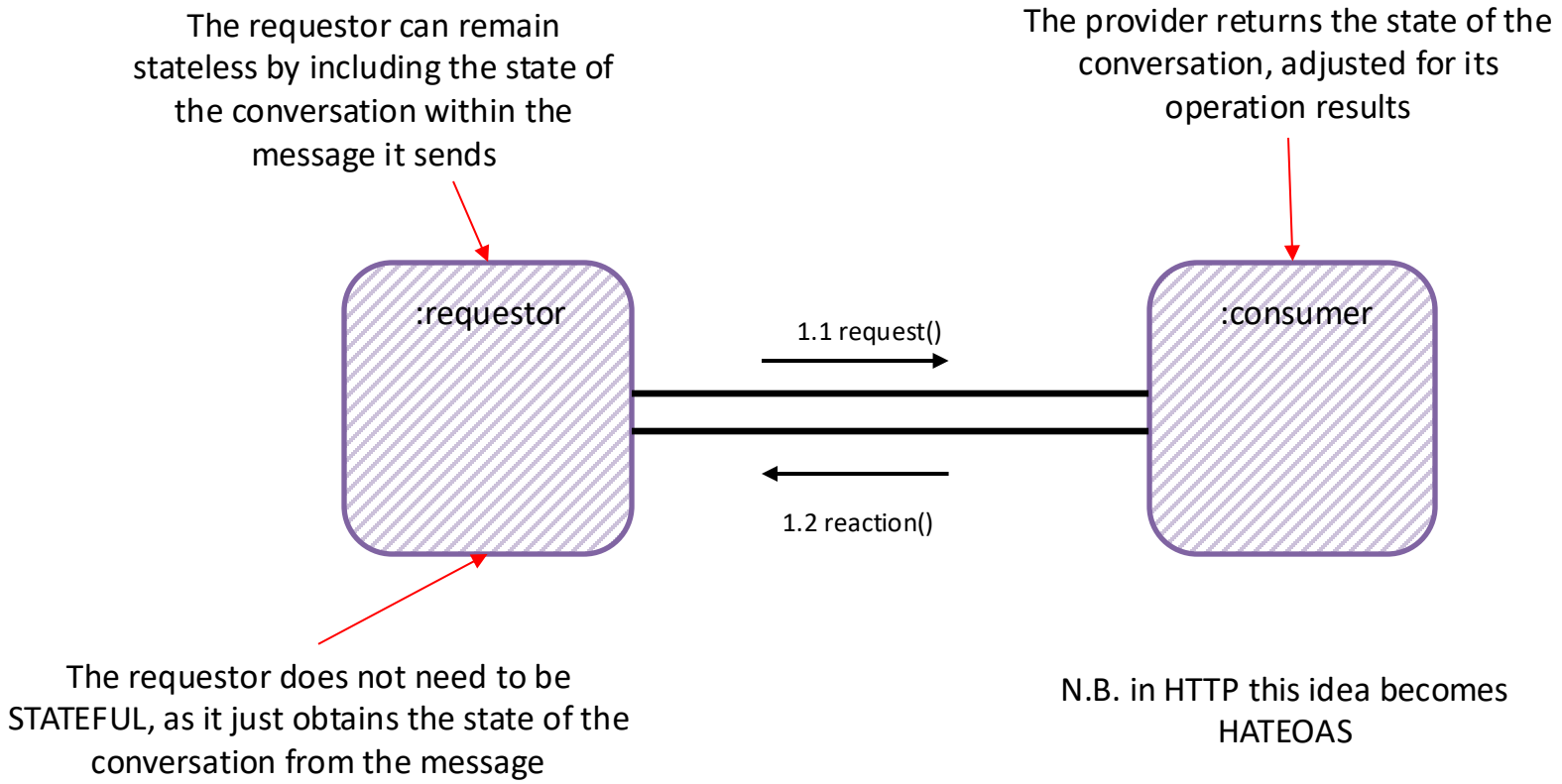
Because the flow is asynchronous, the requestor enters a waiting for response state – as it cannot complete its own operation until it gets the response.

The provider can remain stateless as it only needs to return a response to the requestor

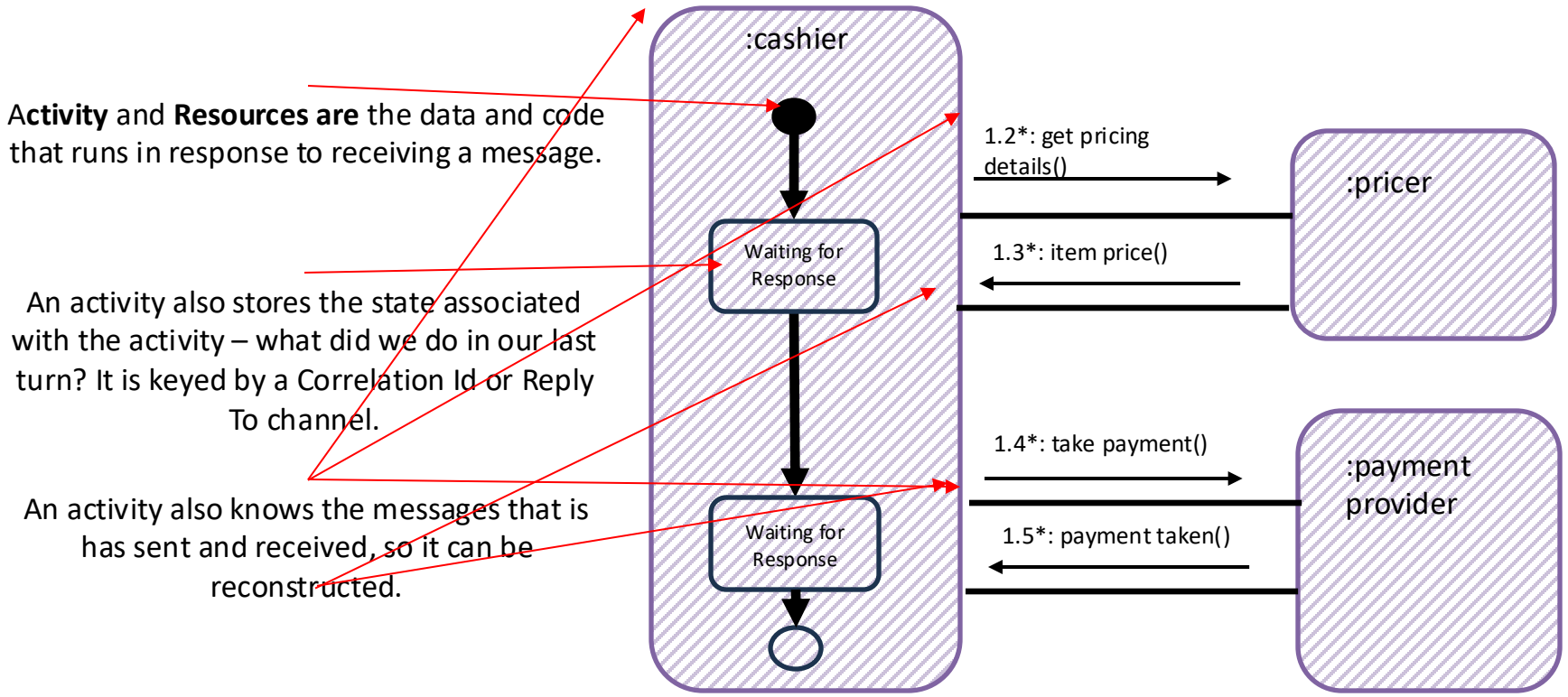


The requestor must be STATEFUL

In-Out (Request-Reaction) Message As Engine of Application State



In-Out (Request-Reaction) Activity and Resources



Activity. Data and computation used to track the work, or part of the work, for a single collaboration.

Resources. Code and data used to manage shared items coordinated across multiple activities such as widgets in inventory or space on a truck needed for a shipment.

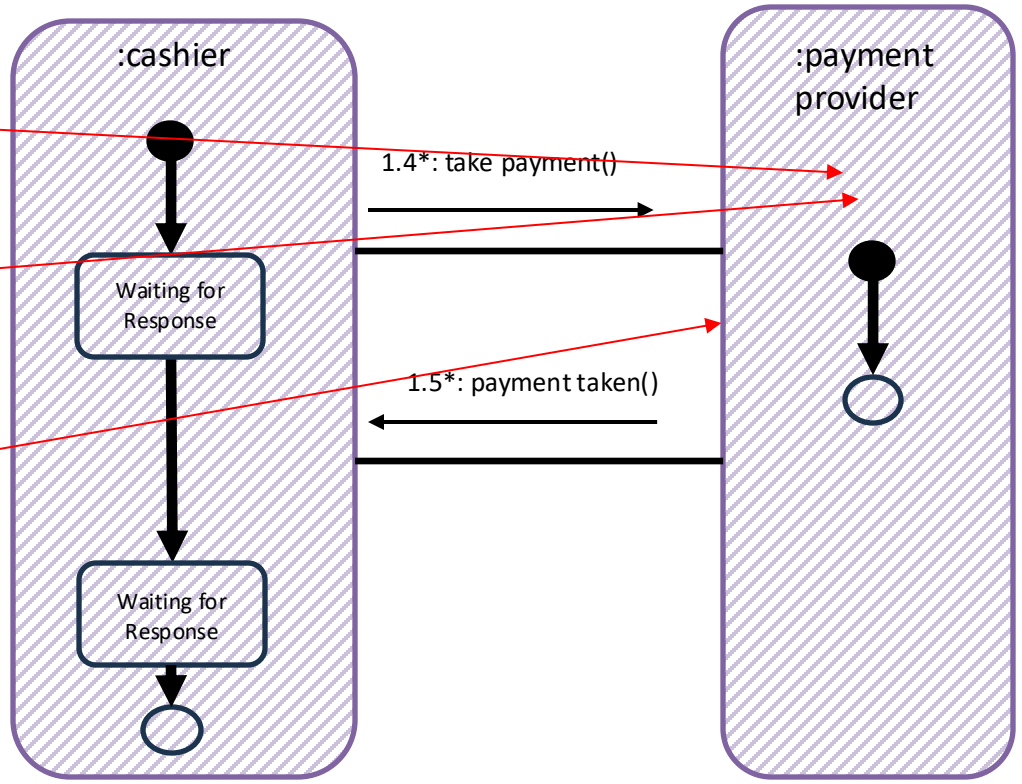
– Path Helland, Autonomous Computing

In-Out (Request-Reaction) Activity and Resources

An **activity** is the code that runs in response to sending a message.

An activity *may* store state associated with the activity – but also may be *stateless* (Message as the Engine of State.)

Each activity also knows the messages that is has sent and received, so the conversation can be reconstructed.



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– Path Helland, Autonomous Computing

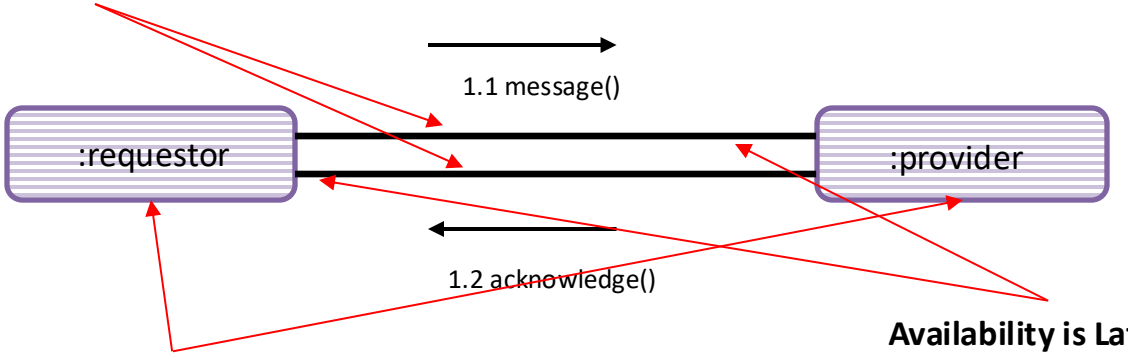
What happens when it all goes wrong

REPAIR AND CLARIFICATION

Failure

Failure Scenarios

Loss of messages, out of order messages, incorrect message schema, loss of broker - a distributed system can fail in many ways.



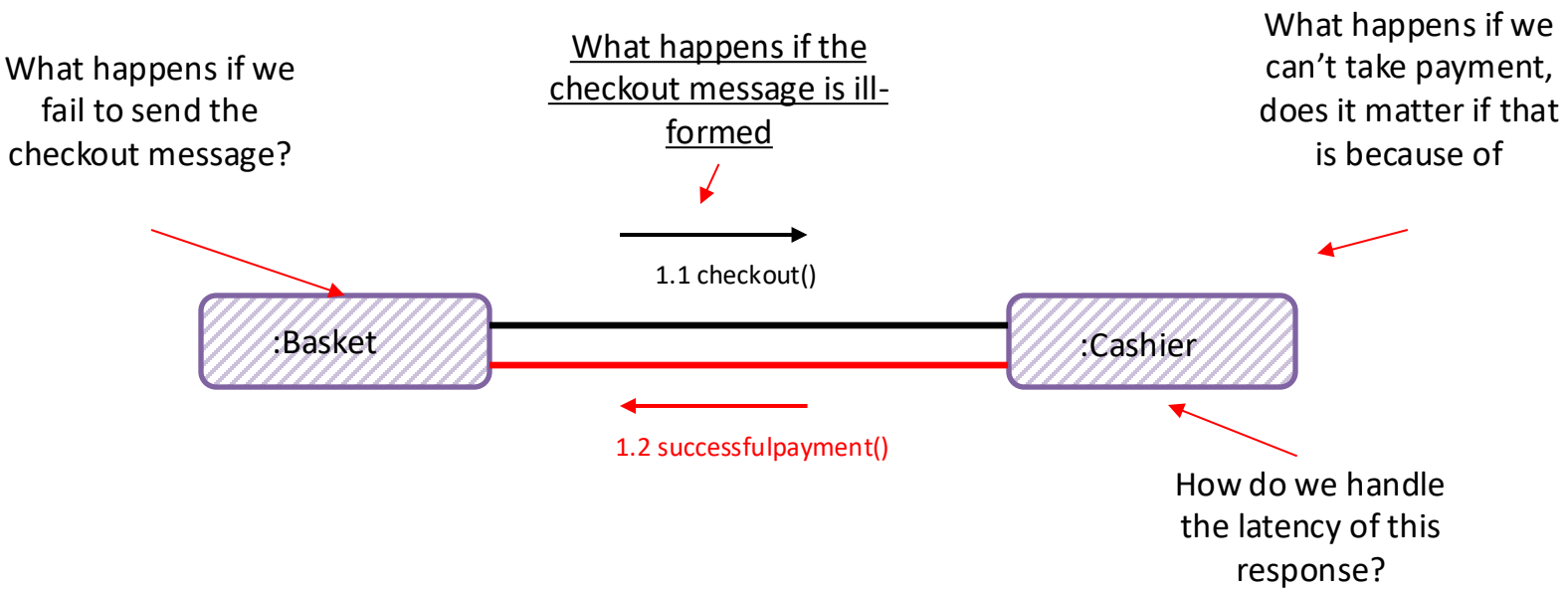
Consistency

How can we know that a consumer received a message or processed it?

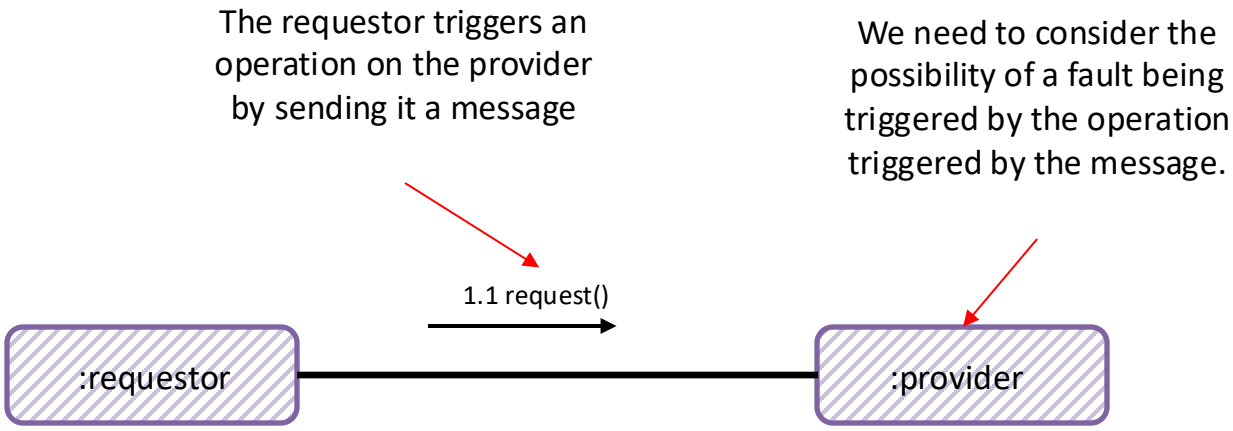
Availability is Latency

We achieve availability by temporal decoupling but this implies that we must cope with latency, even without failure.

Failure


What happens if we fail to send the checkout message?
What happens if the checkout message is ill-formed
What happens if we can't take payment, does it matter if that is because of
1.1 checkout()
:Basket
:Cashier
1.2 successfulpayment()
How do we handle the latency of this response?

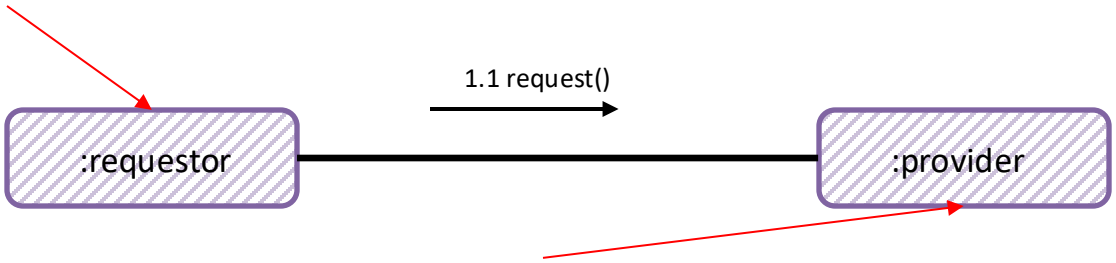
Repair and Clarification



What guarantees does the provider make to the requestor about communicating any faults that are triggered?

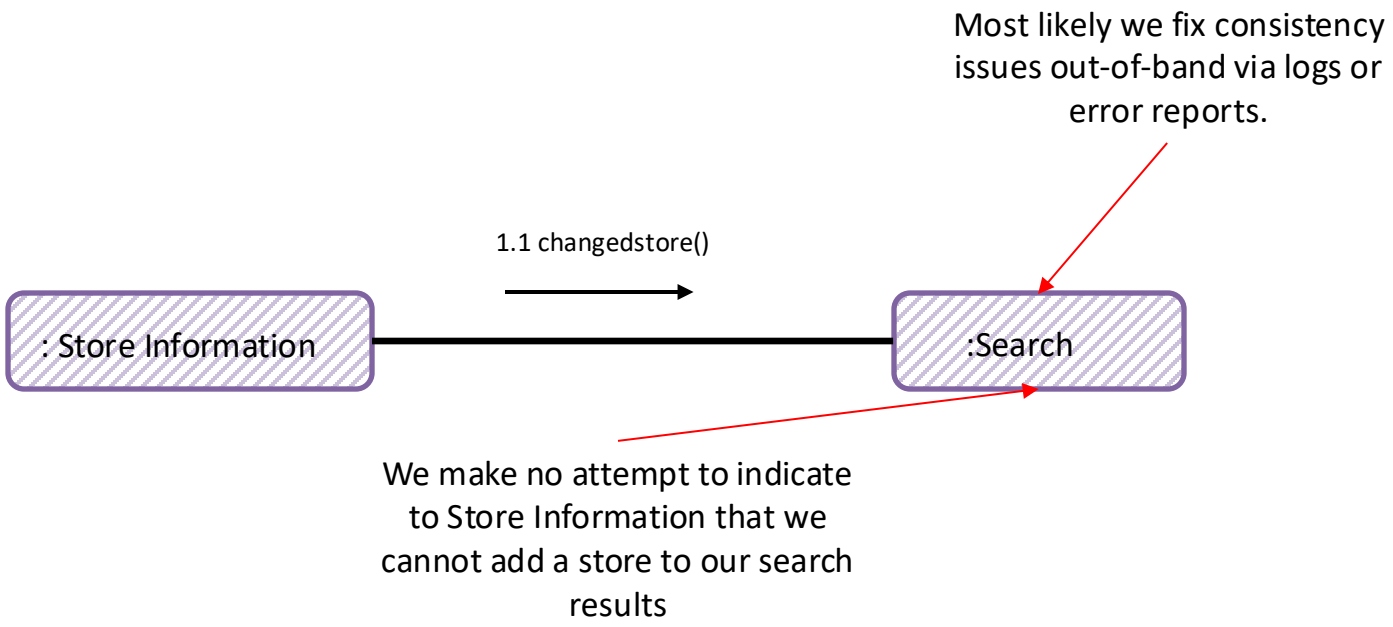
No Fault

From the requestor's perspective, faults are an application issue for the provider, and not its concern



Under a No Fault pattern the provider makes no attempt to communicate triggered faults from the operation to the requestor

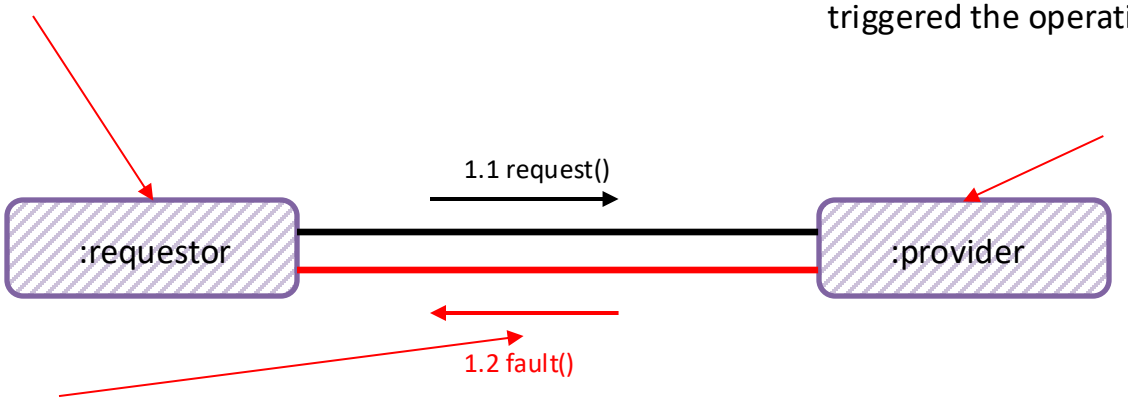
No Fault


Most likely we fix consistency issues out-of-band via logs or error reports.
1.1 changedstore()
: Store Information
:Search
We make no attempt to indicate to Store Information that we cannot add a store to our search results

Message Triggers Fault (Robust In-Only)

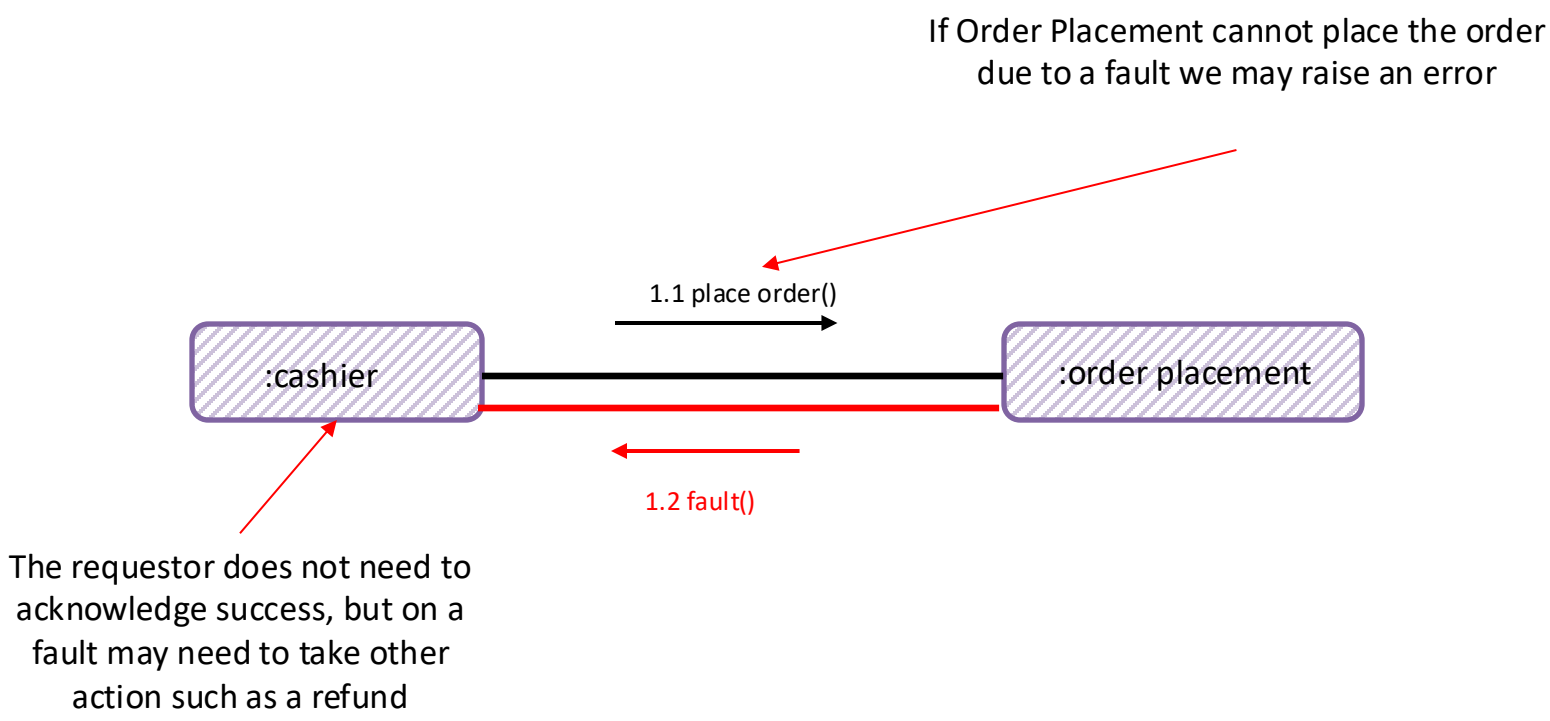
Assumption here is that the requestor can take action on receipt of the fault; but does not normally take a response.

Under Message Triggers Fault pattern a **provider** propagates triggered faults from the operation back to the **requestor** that triggered the operation via a message



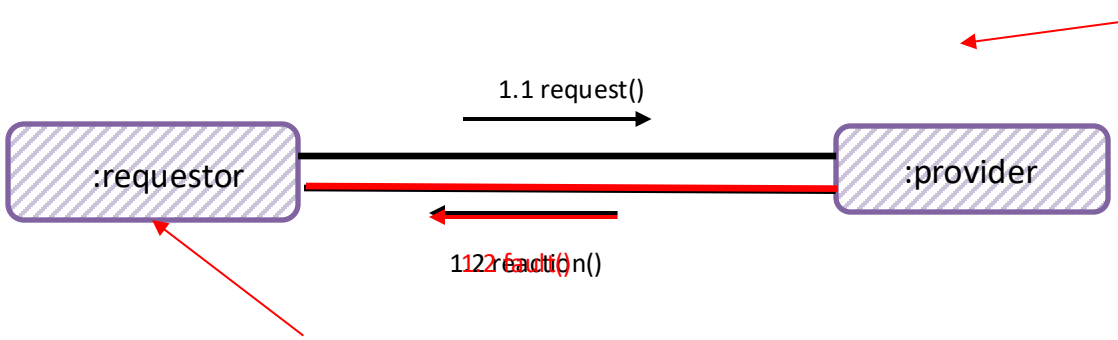
The message must have the opposite direction and go back to the requestor

Message Triggers Fault



Fault Replaces Message

Under the Fault Replaces Message pattern a provider propagates faults triggered by an operation by switching to a fault flow, replacing any message <u>subsequent to</u> the first with a fault.

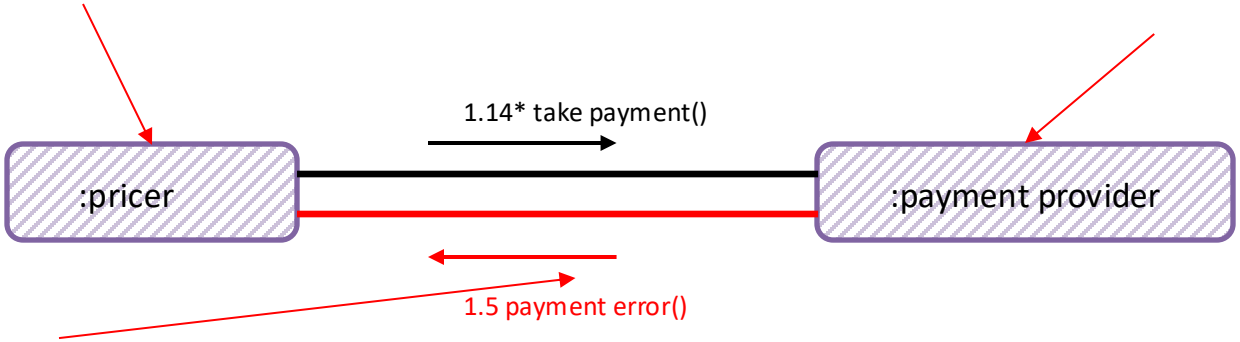


The requestor can handle the error; the error replaces the existing response

Fault Replaces Message (Robust In-Out)

Assumption here is that the pricer can orchestrate a new flow, such as asking for an alternate payment method, or cancel the order.

Under Fault Replaces Message pattern the payment **provider** would signal errors taking a card payment back to the pricer

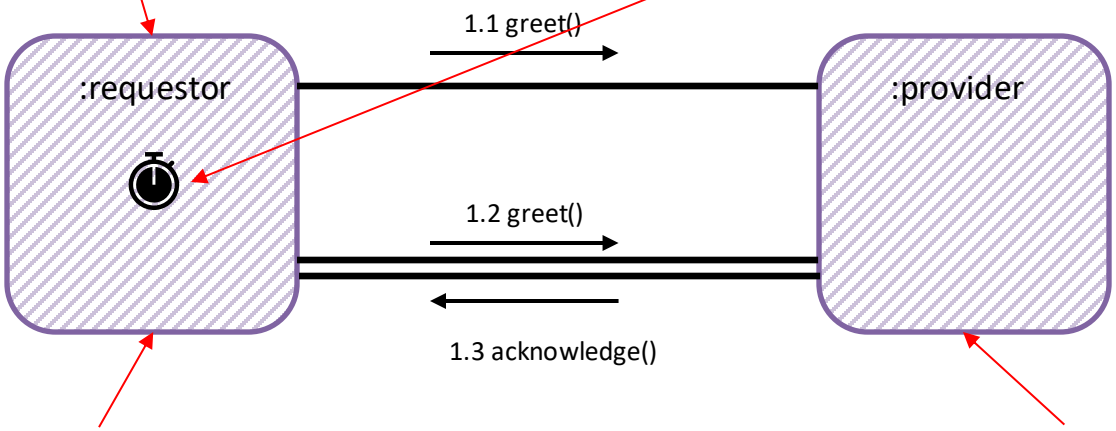


The message should indicate why the payment failed. This might be an issue with the payment provider but it also might be an issue like an invalid card or insufficient funds

In-Out-Retry

The requestor may not receive an expected response from a provider. What can it do?

The requestor can set a timeout within which to receive a response.



The requestor can choose to retry if it does not receive a response within that time window.

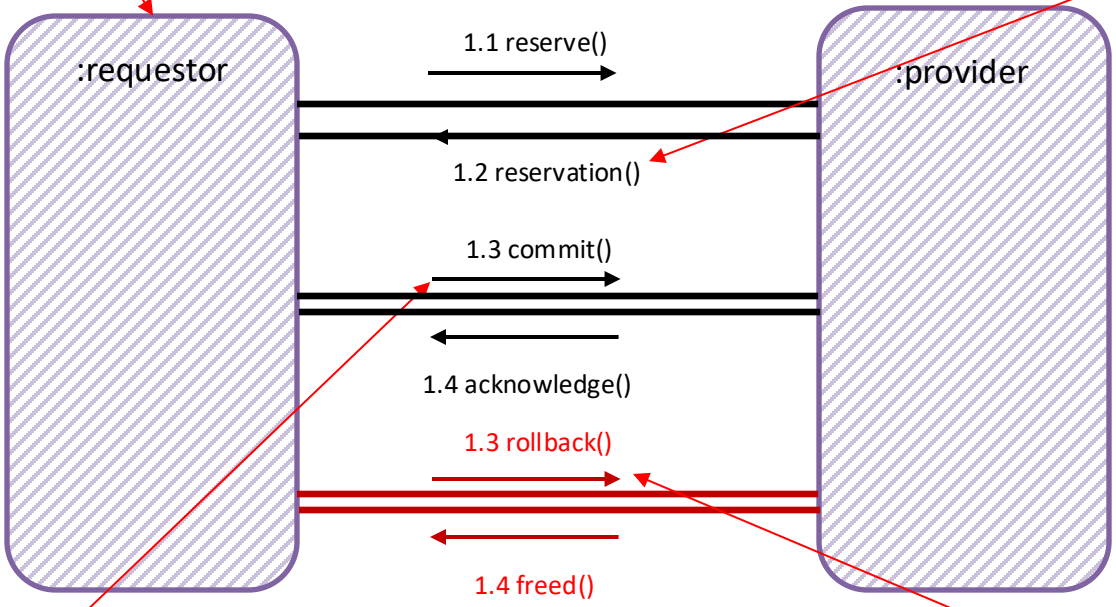
Because we might send a message twice, the operation on the consumer must be idempotent, or the consumer must de-duplicate already seen messages

Tentative Operations

The requestor may not know if the provider will be able to succeed, and might not want to proceed without knowing that

The requestor asks if the operation is possible, and reserves the resources to perform it.

The provider reserves the resource – usually with a timeout – during which time it awaits a message to commit or rollback



If the requestor completes its work, it then commits to ask the provider to allocate the reserved capacity.

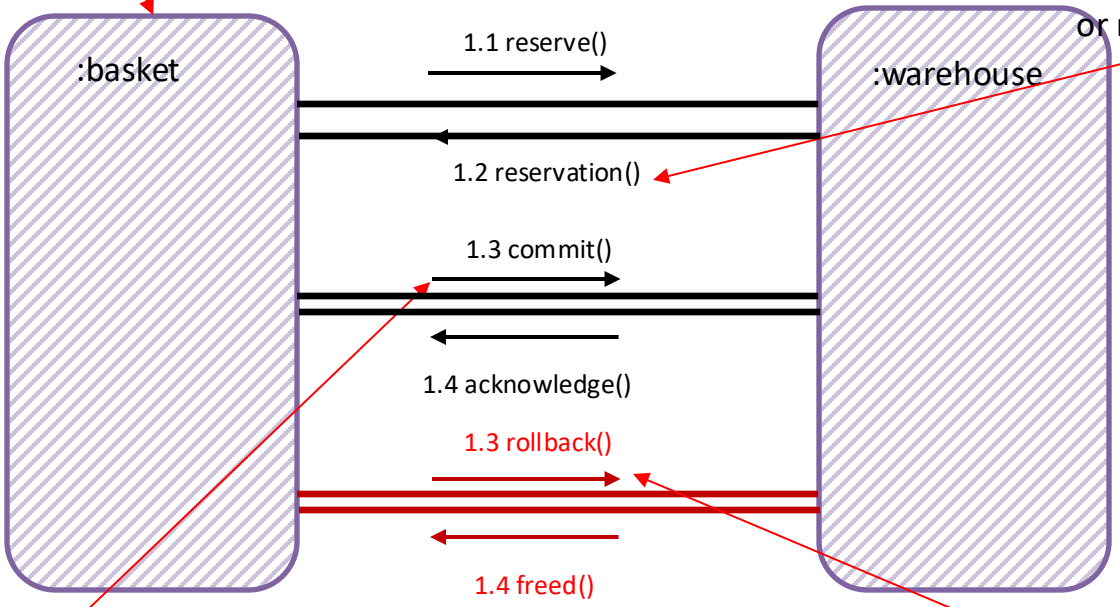
If the requestor fails, it then rolls back to ask the provider to free the reserved capacity.

Tentative Operations

We don't want to purchase the item if the stock is not available

The basket asks the warehouse if there is stock, and if so reserves it. Fault could replace message here, if the item is out-of-stock

The warehouse reserves the stock – with a timeout (so others can purchase if we don't) – during which time it awaits a message to commit or rollback



If the customer finishes shopping and pays for the basket before the time limit, then it commits to ask the warehouse to allocate the stock.

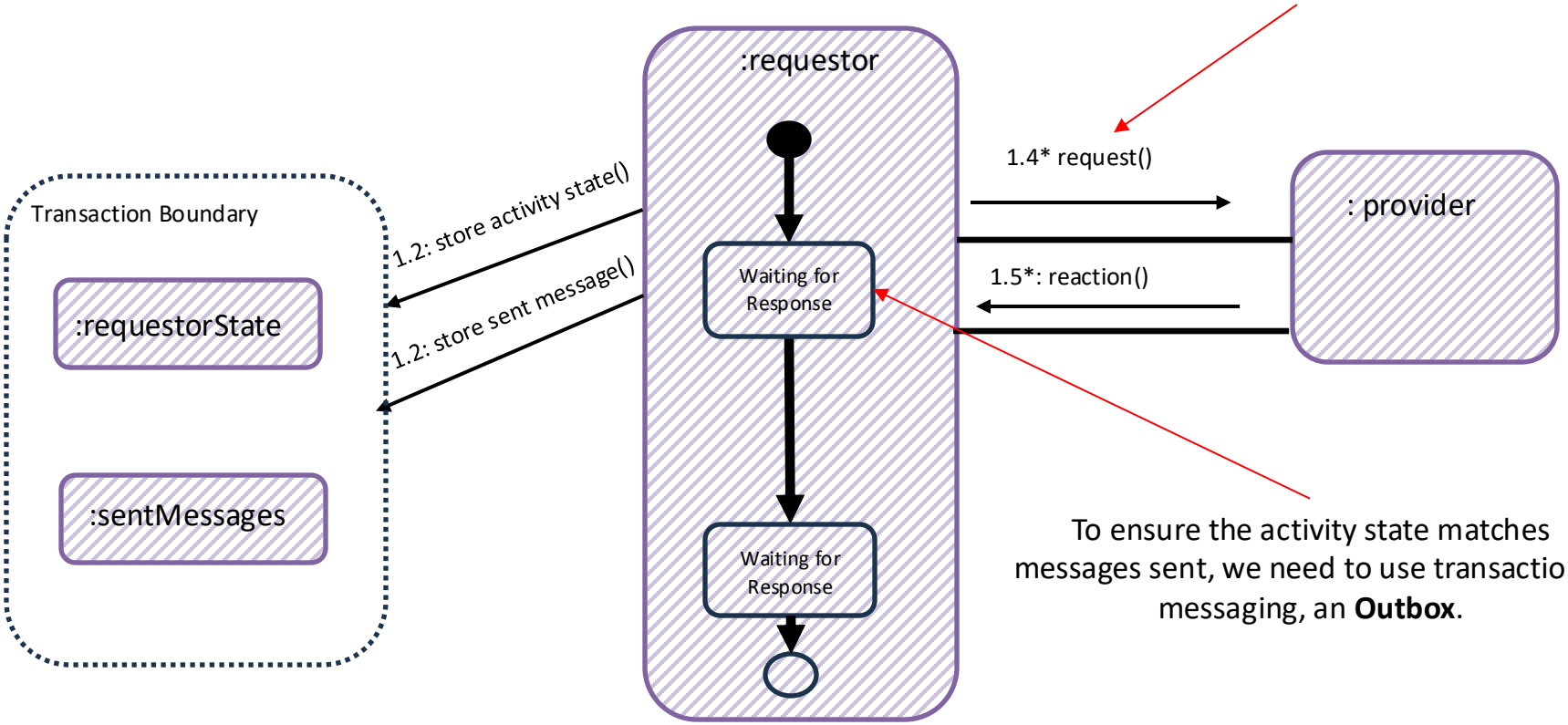
If the basket does not complete, then it rolls back to ask the warehouse to free the stock.

How do we ensure that our messaging is reliable?

RELIABLE MESSAGING

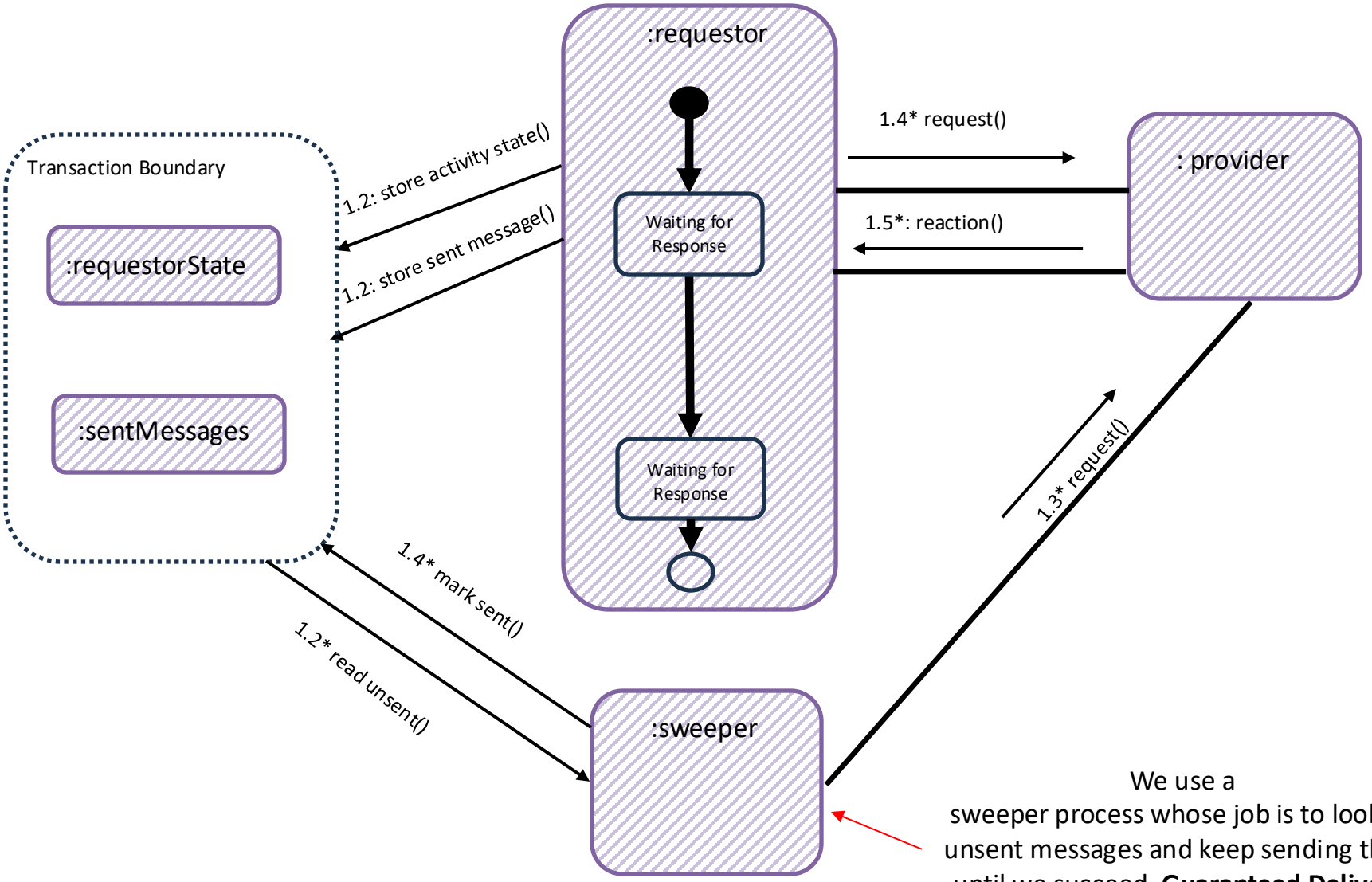
Reliable Messaging – Outbox

Sending the message might fail, this would result in our requestor's state being incorrect – it's waiting for a response it will never get!

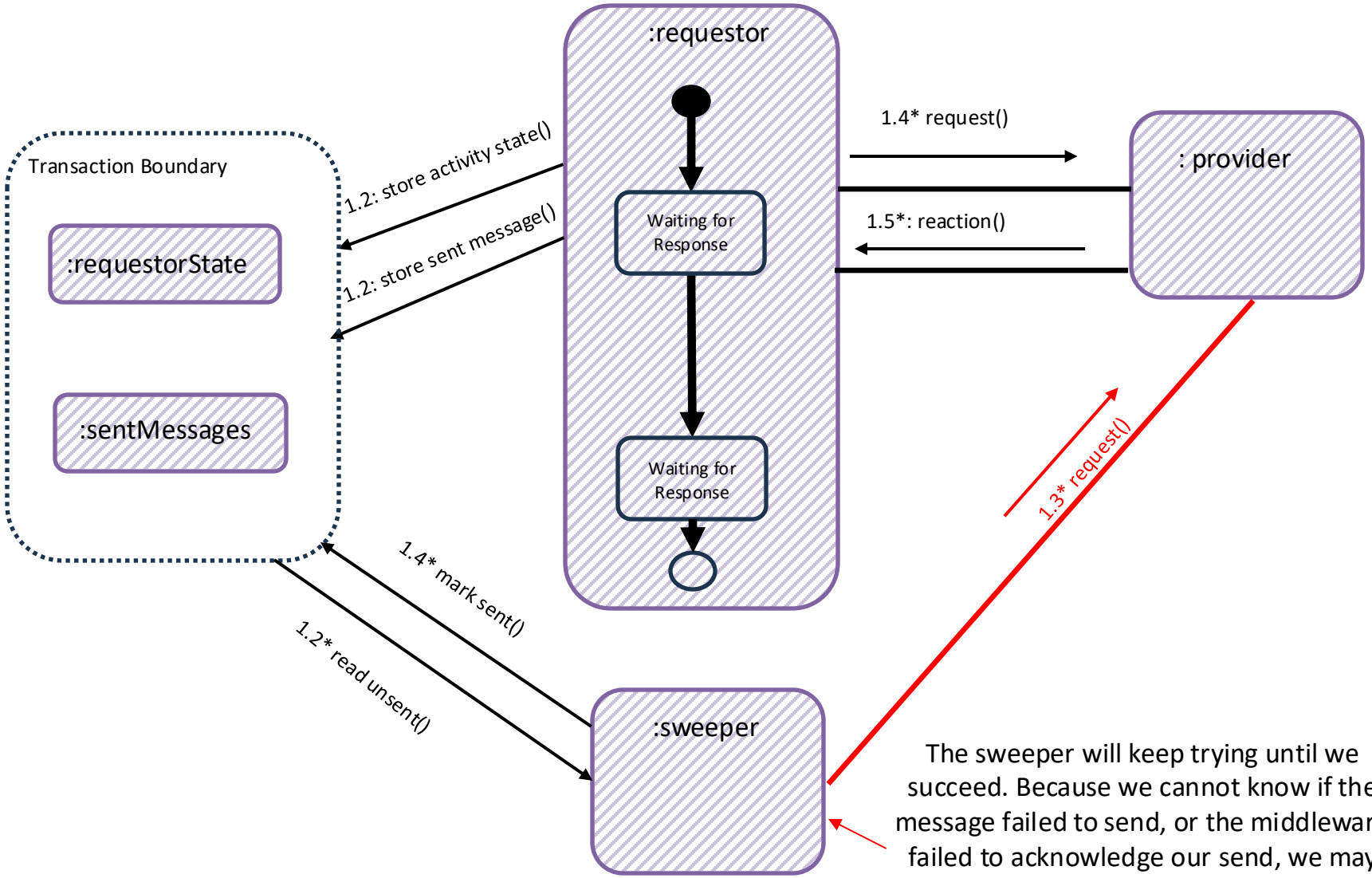


To ensure the activity state matches messages sent, we need to use transactional messaging, an **Outbox**.

Reliable Messaging – Outbox - Guaranteed Delivery

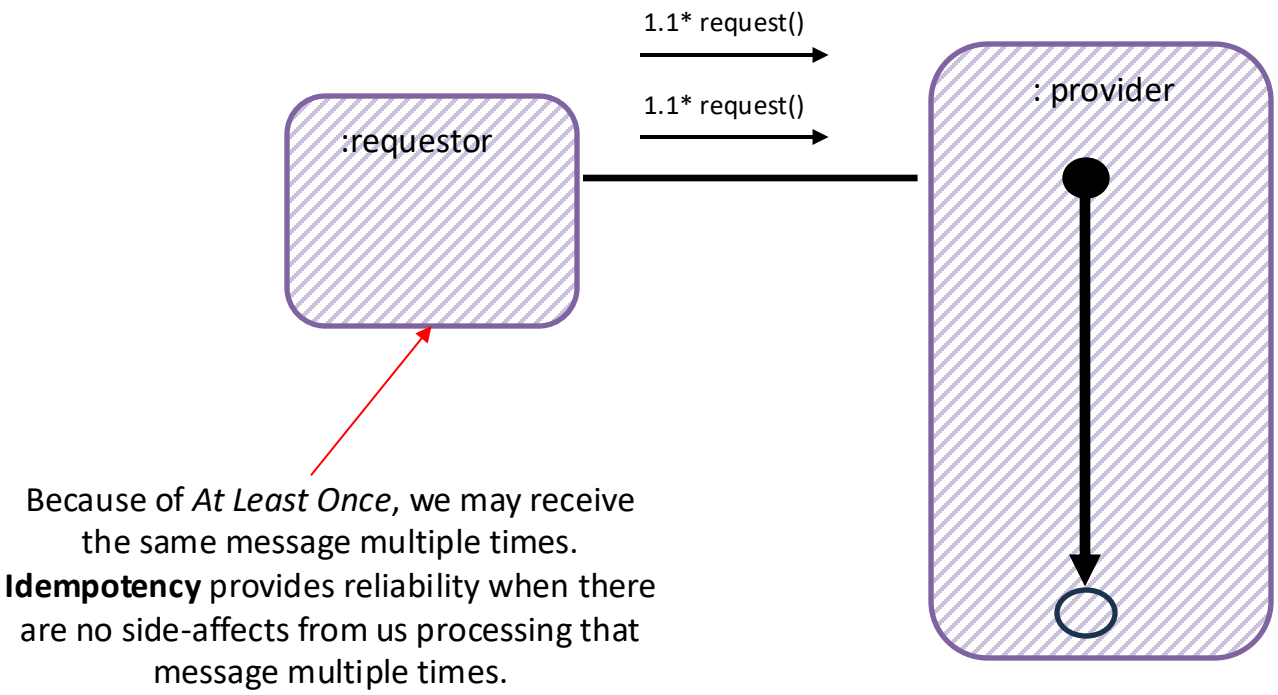


Reliable Messaging – At Least Once

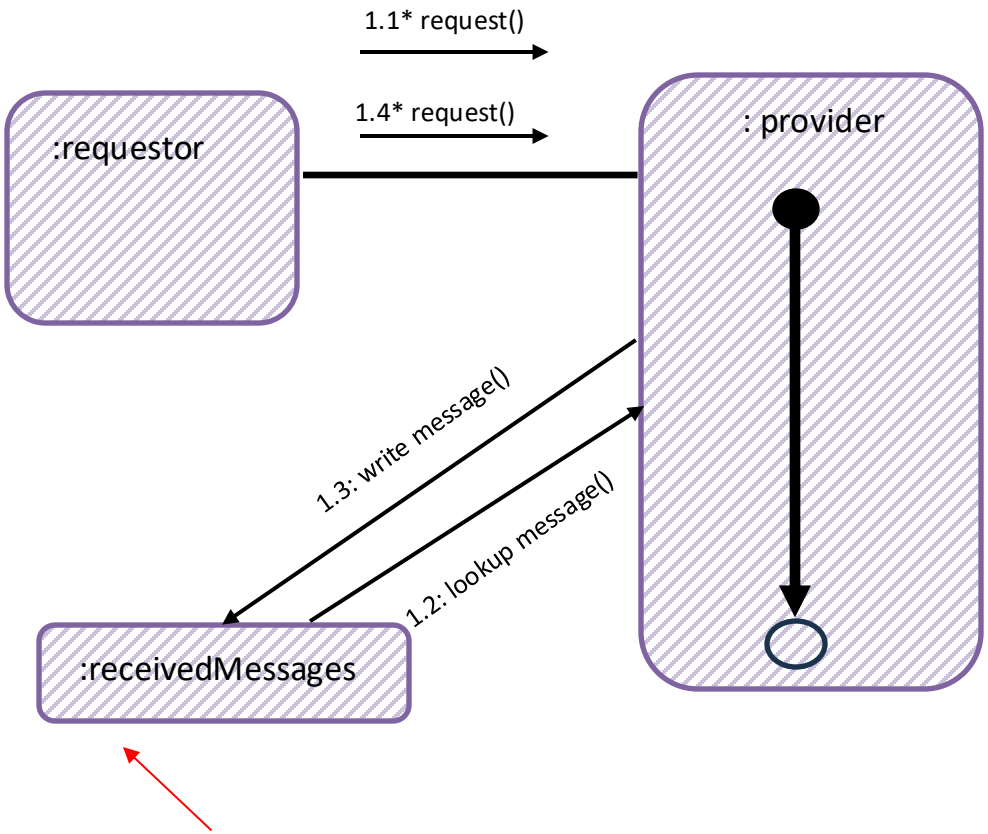


The sweeper will keep trying until we succeed. Because we cannot know if the message failed to send, or the middleware failed to acknowledge our send, we may resend a message that has been sent. **At Least Once.**

Reliable Messaging - Idempotency

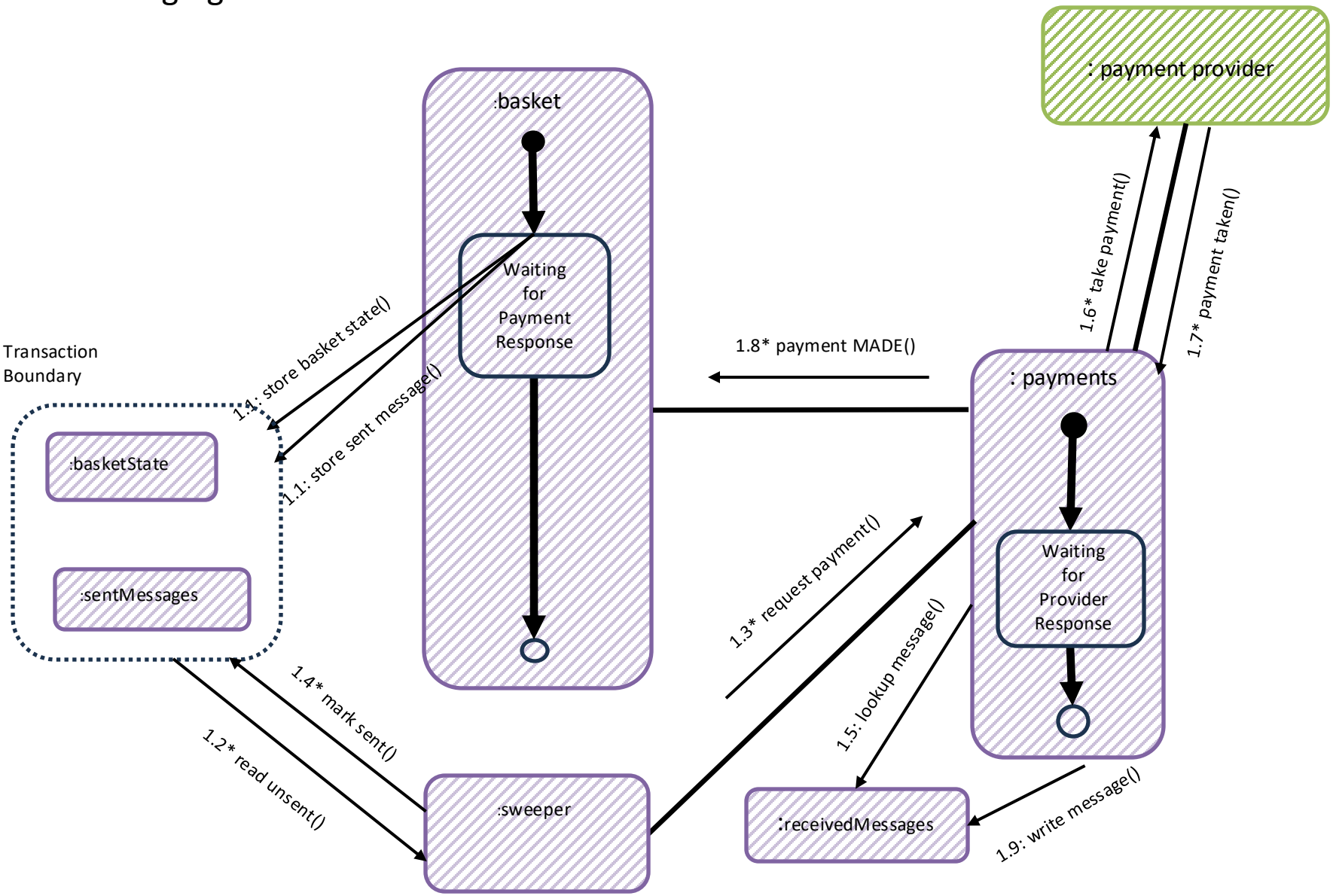


Reliable Messaging - Inbox



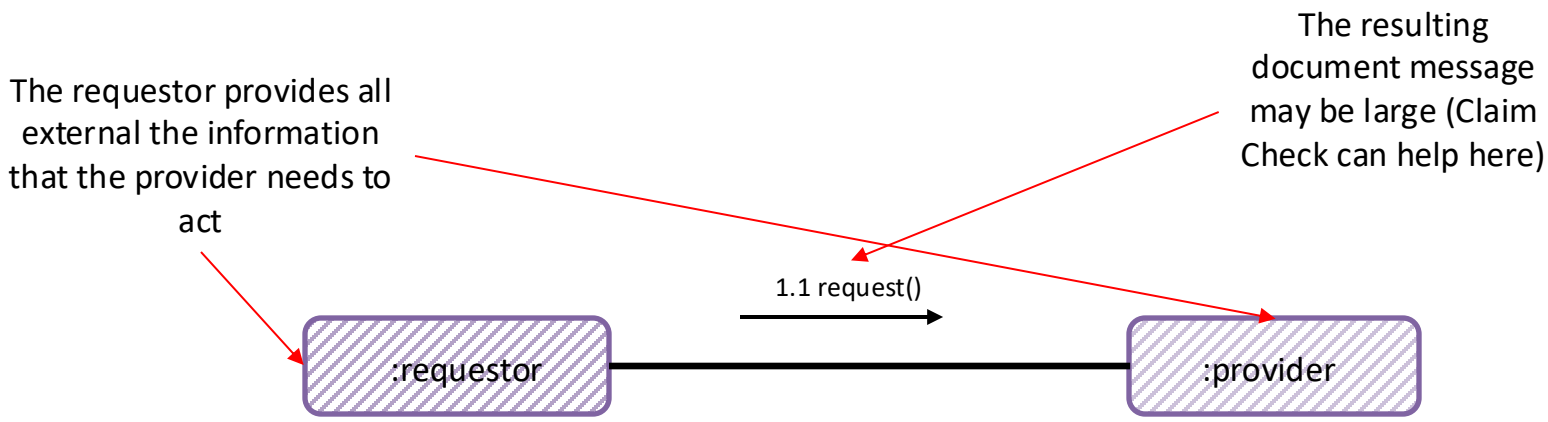
Because of *At Least Once*, to ensure that we have not already processed a message, we store seen messages, an **Inbox**. We turn *At Least Once* into **Once Only**.

Reliable Messaging



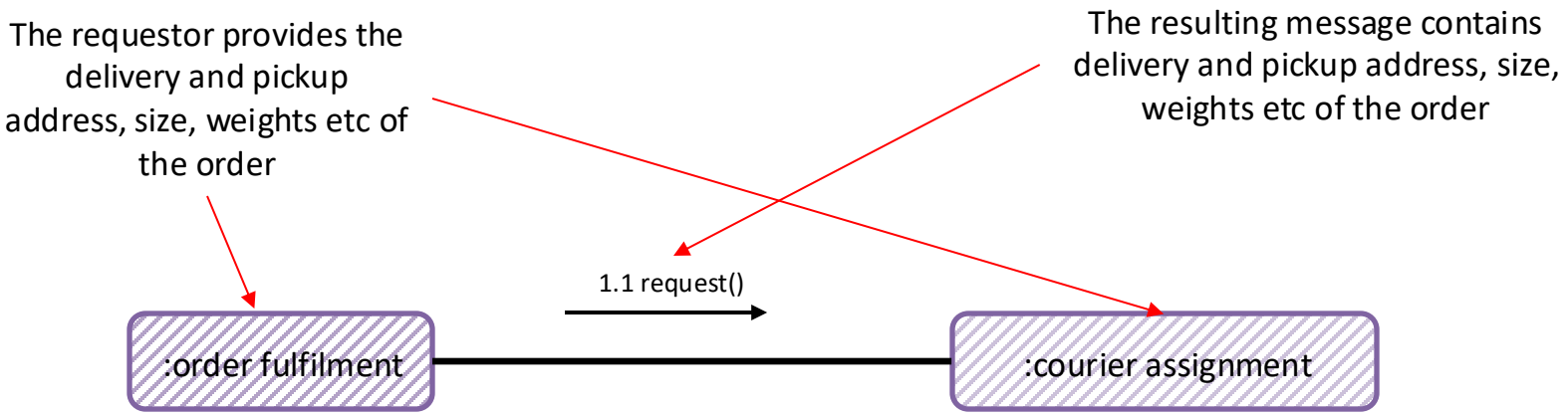
FAT AND SKINNY

Fat Message



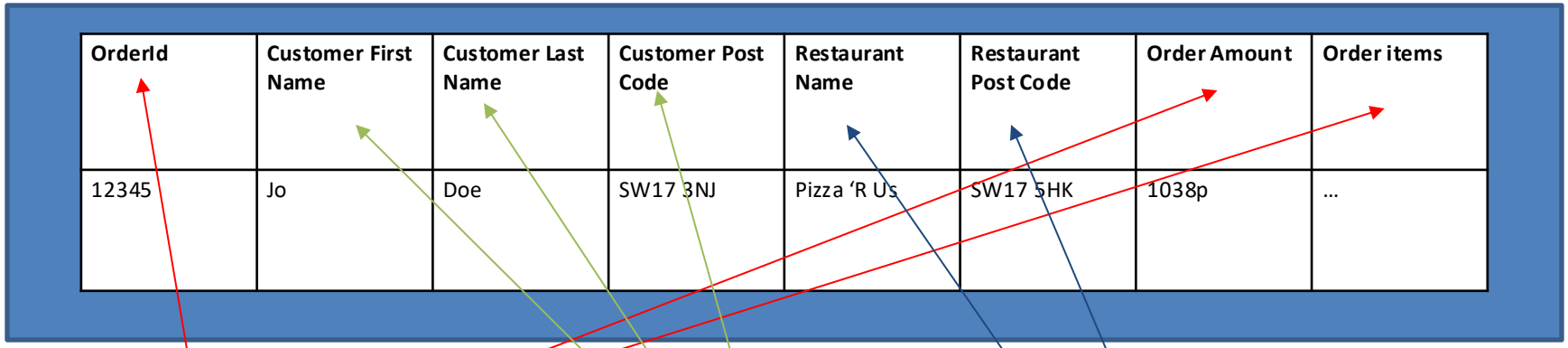
With a **Fat Message** the requestor sends across all the external information a provider may need to perform the operation.

Fat Message Example



Fat Message, Transitive Dependencies

Purchase Order Message



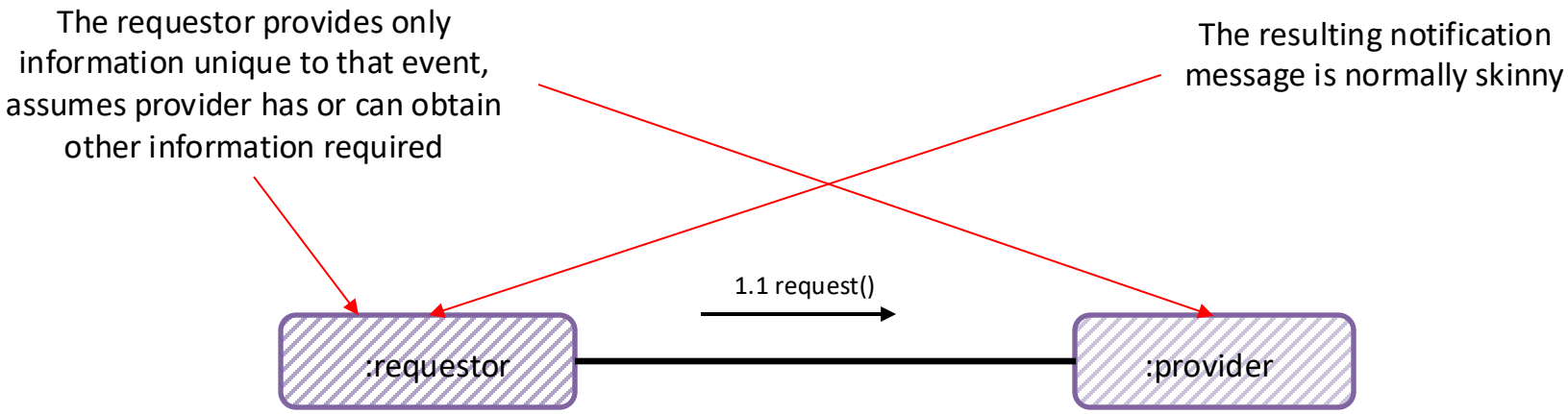
OrderId	Customer First Name	Customer Last Name	Customer Post Code	Restaurant Name	Restaurant Post Code	Order Amount	Order items
12345	Jo	Doe	SW17 3NJ	Pizza 'R Us	SW17 5HK	1038p	…

This data has a lifetime of the message i.e. the purchase order and their schema changes if the purchase order changes

This data is a **transitive dependency**, it has a lifetime of the Customer and their schema changes if the Customer schema changes – which may force us to change the message for Customer changes

This data is a **transitive dependency**, it has a lifetime of the Restaurant and their schema changes if the Restaurant schema changes – which may force us to change the message for Restaurant changes

Skinny Request

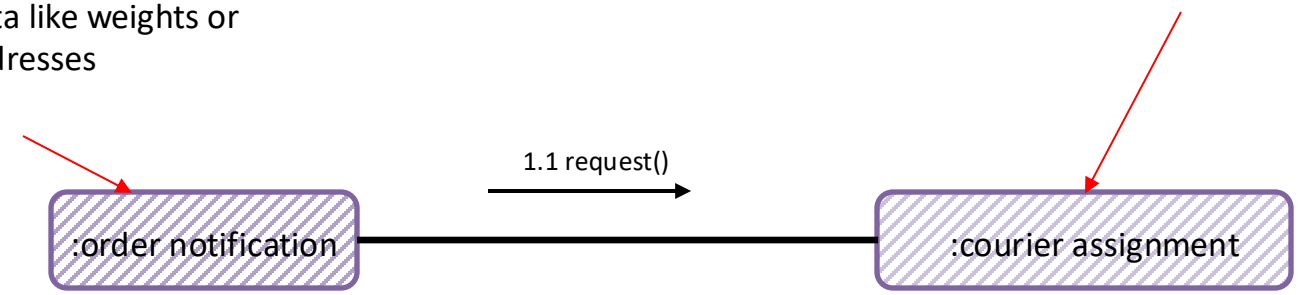


With a **Skinny Request** the requestor assumes the provider has necessary external information to perform the operation.

Skinny Request, Example

The requestor provides a notification that there is an order, but only inlines data that is unique to the order not reference data like weights or addresses

Courier assignment needs information that is not on the order: weights, addresses. It has to source that from elsewhere



Skinny Message, Normalized

Purchase Order Message

OrderId	Order Amount	Order items	CustomerId	RestaurantId
12345	1038p	…		

Customer

Customer First Name	Customer Last Name	Customer Post Code
Jo	Doe	SW17 3NJ

We use an Id where the data does not share the lifetime of the message; we assume the requestor obtains the data out-of-band

Restaurant

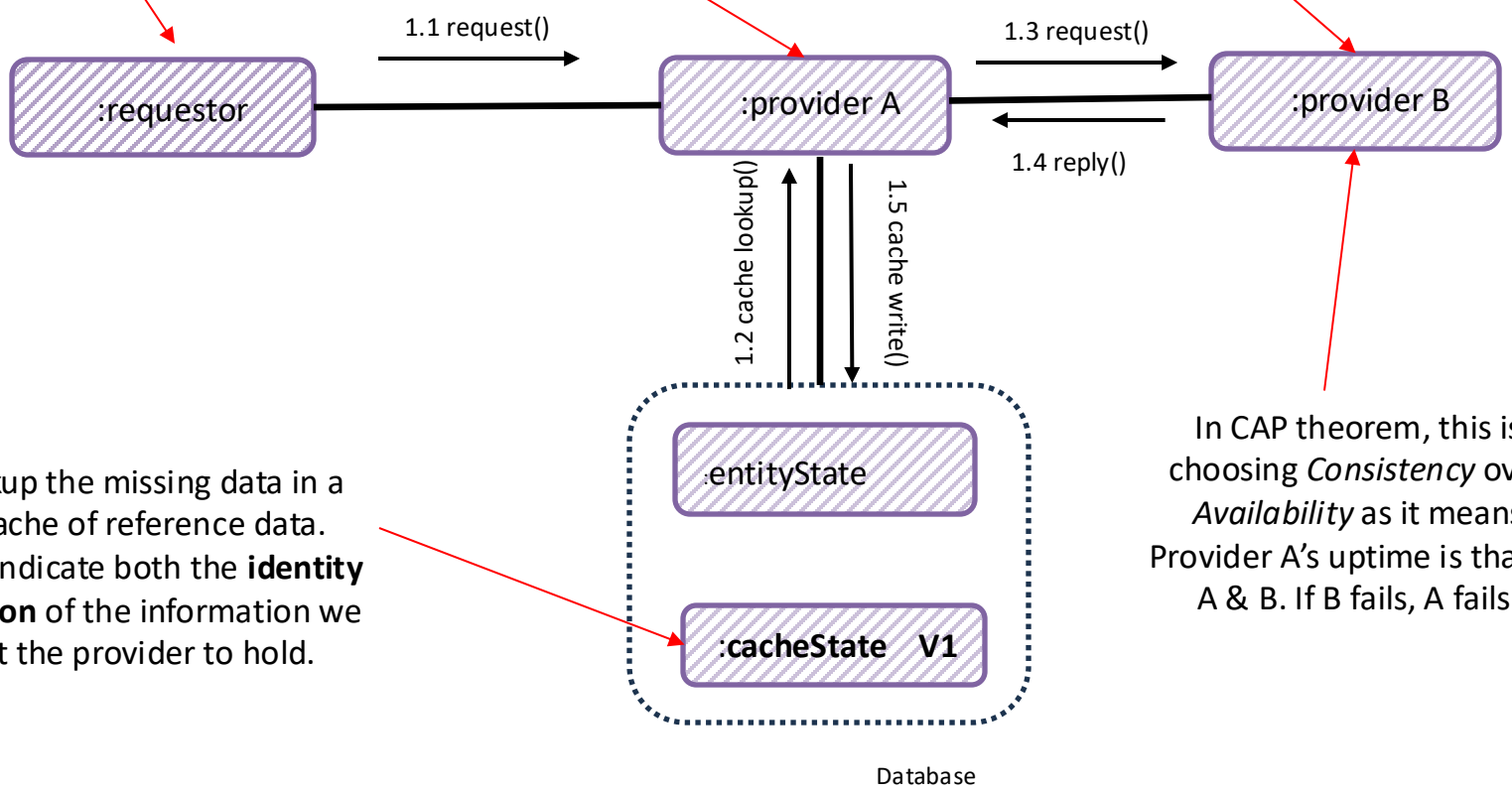
Restaurant Name	Restaurant Post Code
Pizza ‘R Us	SW17 5HK

We need to lookup this id with other providers

Skinny Request via REST/RPC

The requestor provides only information unique to that event, assumes *provider A* has or can obtain information from *provider B*

On a cache miss we request the data from provider B, and store it in the cache. The cache is choosing *Availability* over *Consistency*, **except** on a miss.



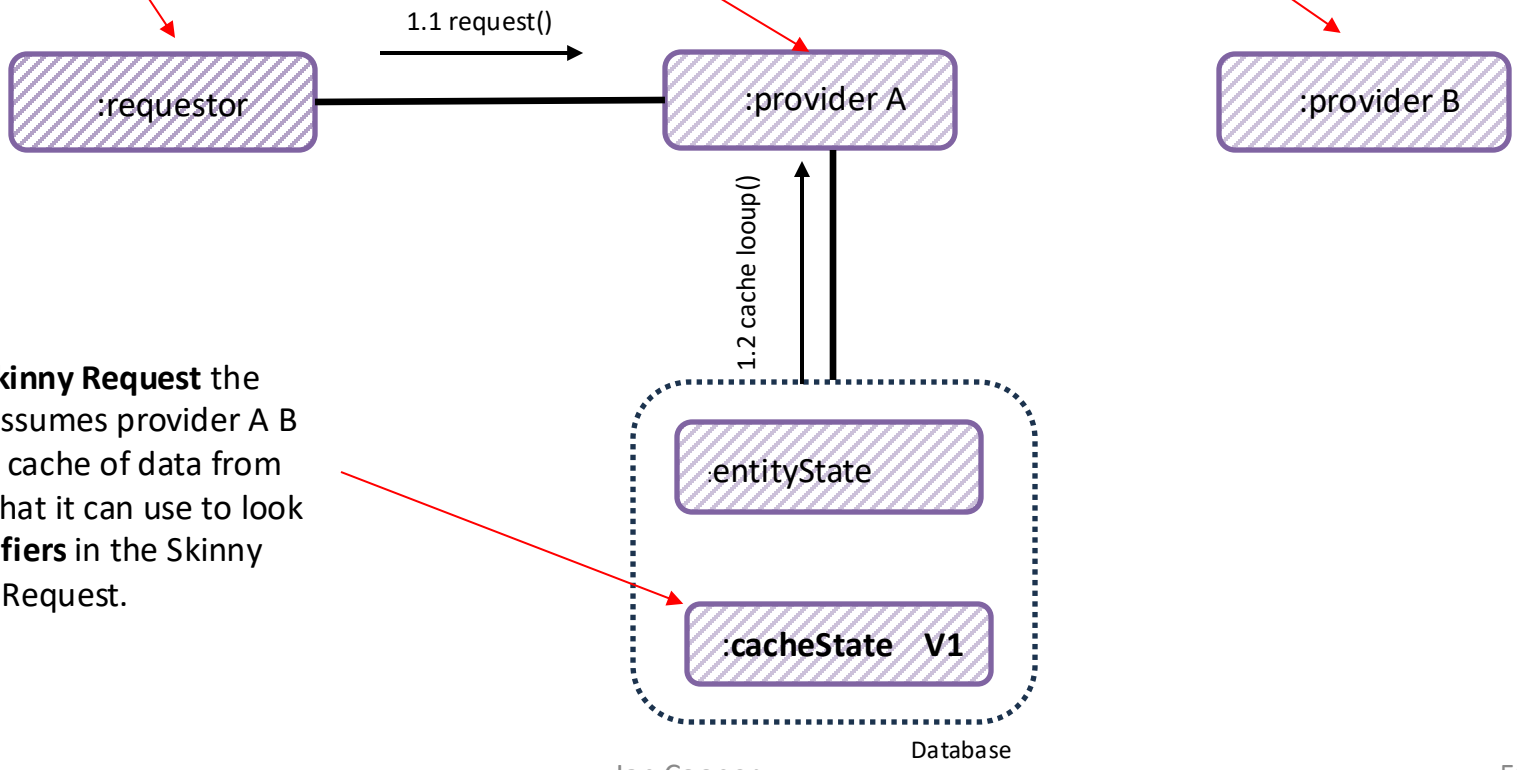
We lookup the missing data in a local cache of reference data. We may indicate both the **identity** and **version** of the information we expect the provider to hold.

In CAP theorem, this is choosing *Consistency* over *Availability* as it means Provider A's uptime is that of A & B. If B fails, A fails.

Skinny Request using Reference Data

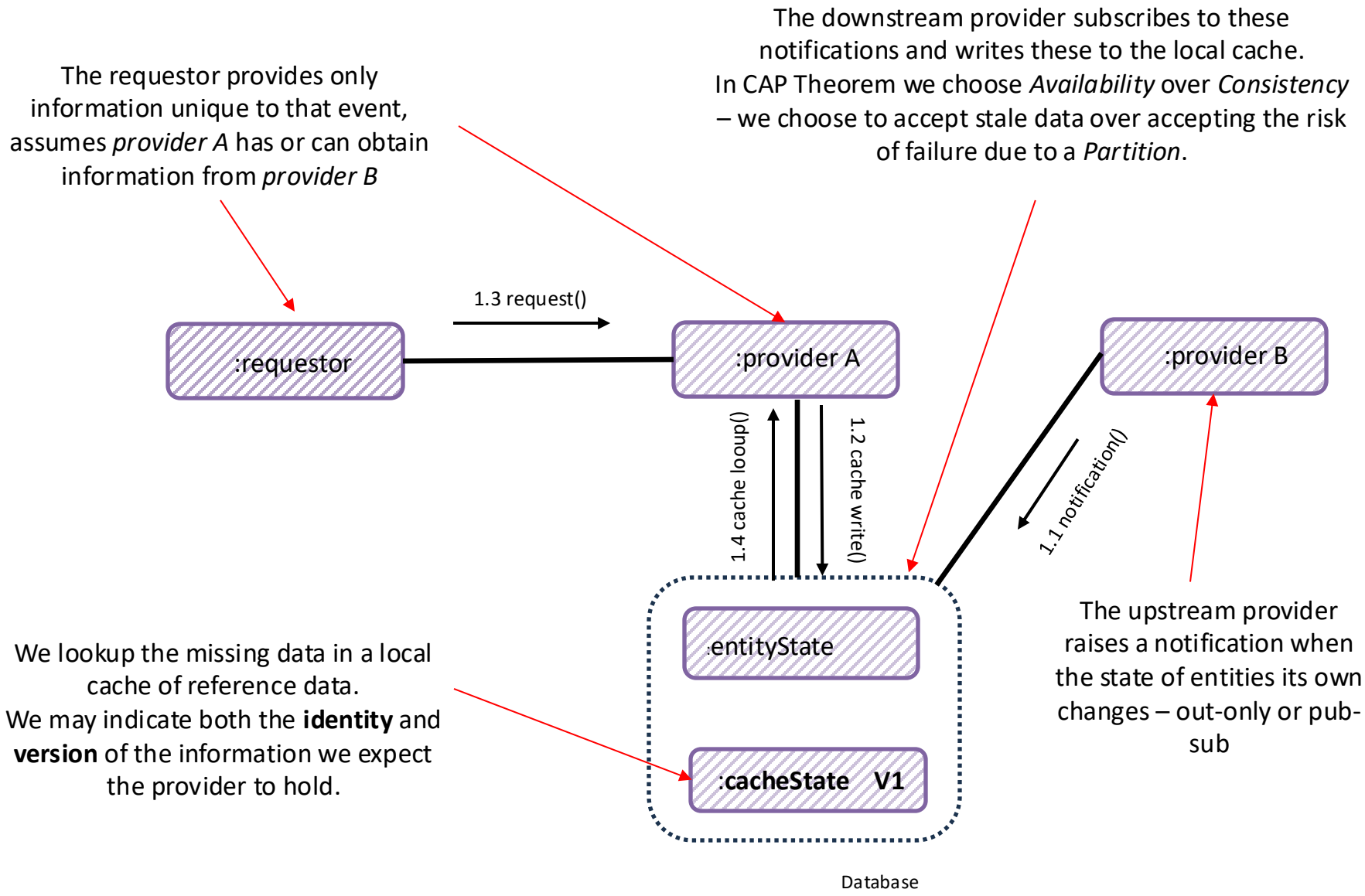
Data that leaves Provider B via an API is **Reference Data**.
It is:
- *Immutable*
-*Versioned*
-*Stale*
It can be cached locally to provider A to prevent the need for frequent lookups

The requestor provides only information unique to that event, assumes *provider A* has or can obtain information from *provider B*

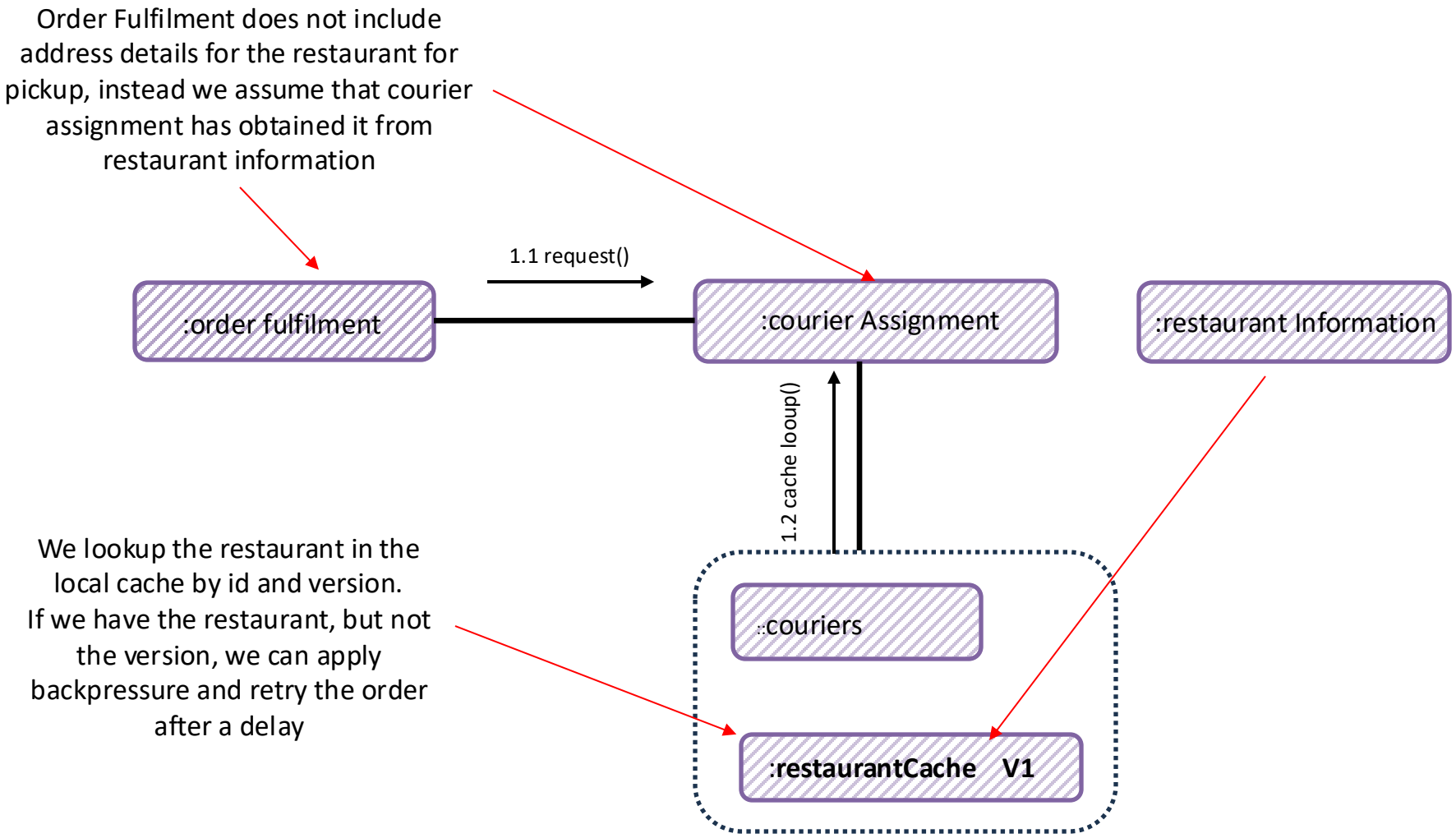


With a **Skinny Request** the requestor assumes provider A B has a local cache of data from provider B that it can use to look up **identifiers** in the Skinny Request.

Skinny Request, Reference Data via ECST (Event Carried State Transfer)



Skinny Request using Reference Data

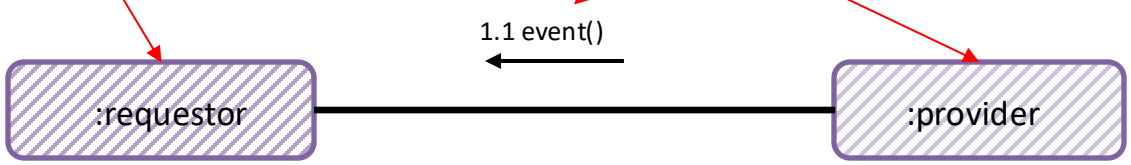


DOMAIN, SUMMARY, ORDERING

Domain Event

An approach to Pub-Sub where the provider communicates **granular** state changes to its requestors

The resulting message is usually a past participle named after the command that caused the change i.e. *BasketItemRemoved*, *BasketItemAdded*



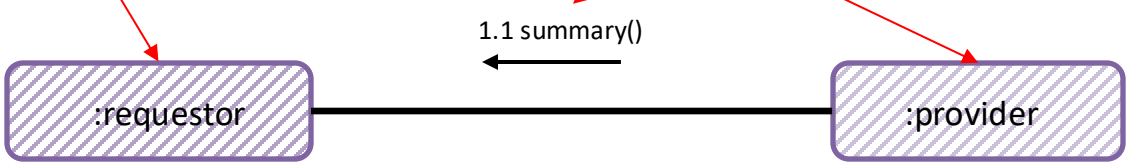
With a **Domain Event** the provider cannot use a *DataType Channel* as the domain events for the observable must be ordered on the same channel, and have a different schema.

This puts an additional burden on the requestor to multiplex handling the event

Summary Event

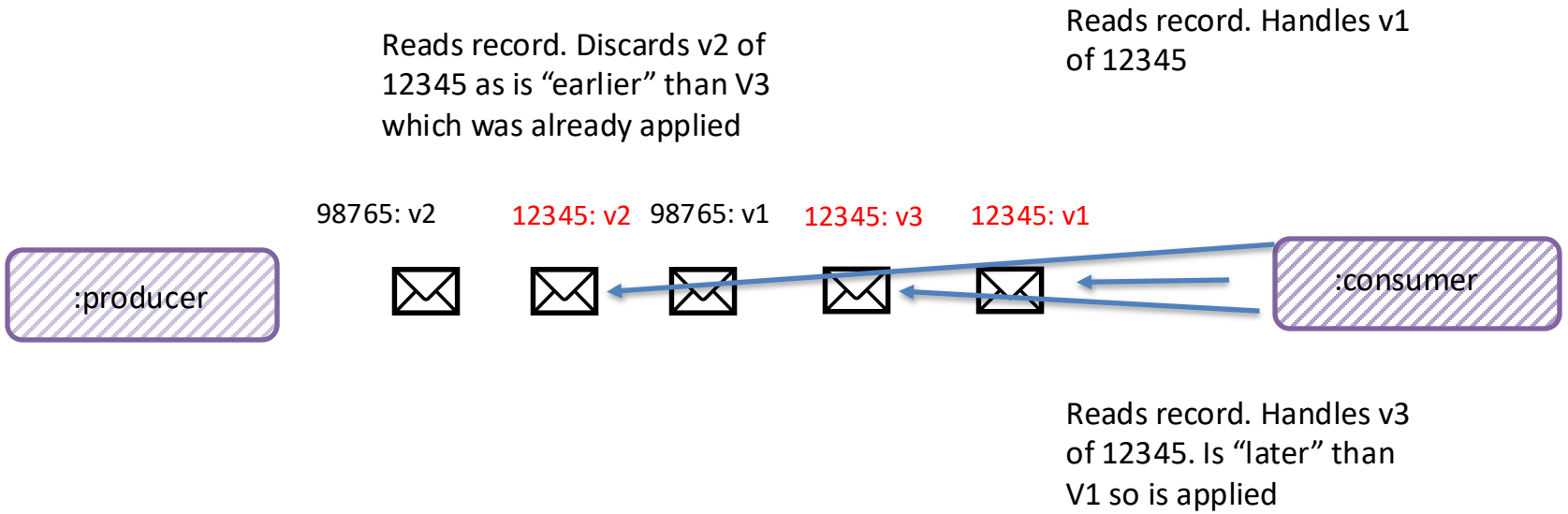
An approach to Pub-Sub where the provider communicates **a summary** of state changes to its requestors

The resulting message is **versioned** and contains *metadata describing the cause(s)* of any changes. It is usually named after the observable in the pub-sub i.e. *BasketChanged*



With a **Summary Event** the provider can uses a *DataType Channel* as there is just one schema used to communicate a snapshot of the observable.

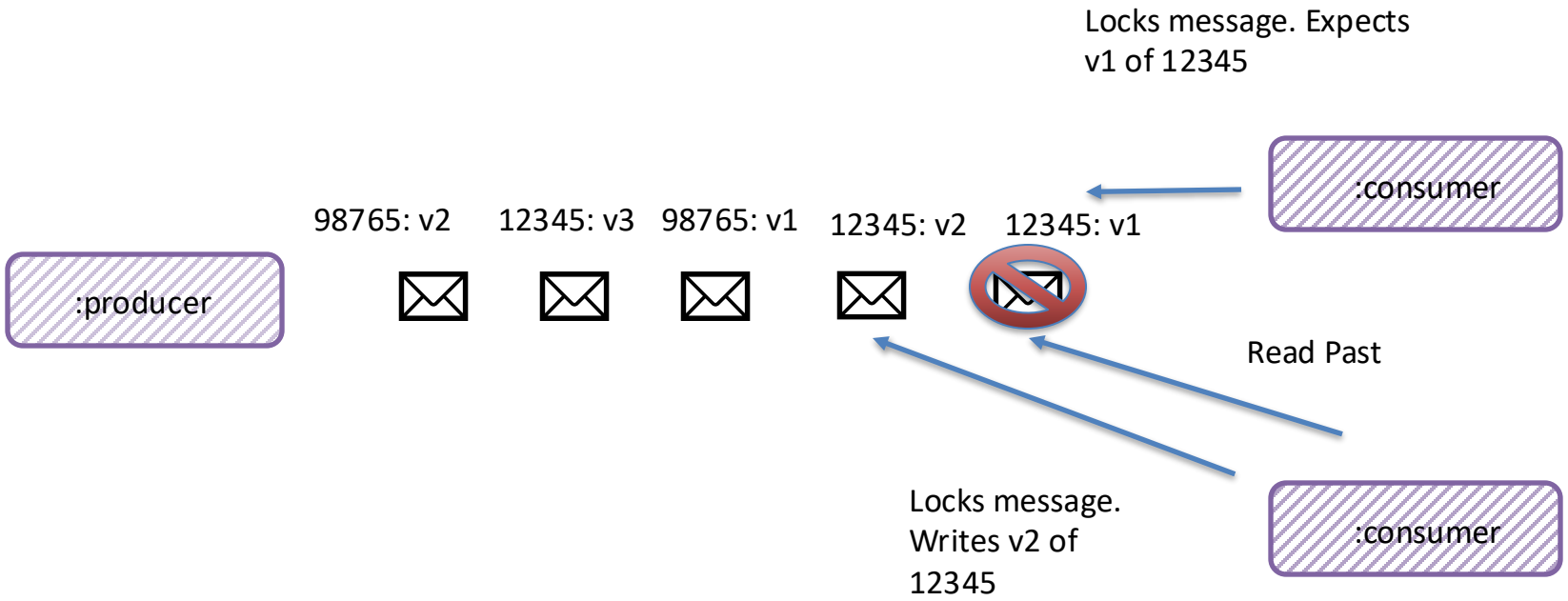
If Later, Stream



If Later allows us to use a versioned **Summary Event** to ignore ordering errors. Even on a stream, a non-blocking retry or guaranteed delivery via an outbox may result in out-of-order messages. We can also shed load

We cannot use If Later with a **Domain Event,** as they all must be applied. We can only use a blocking retry with a Domain Event and cannot shed load.

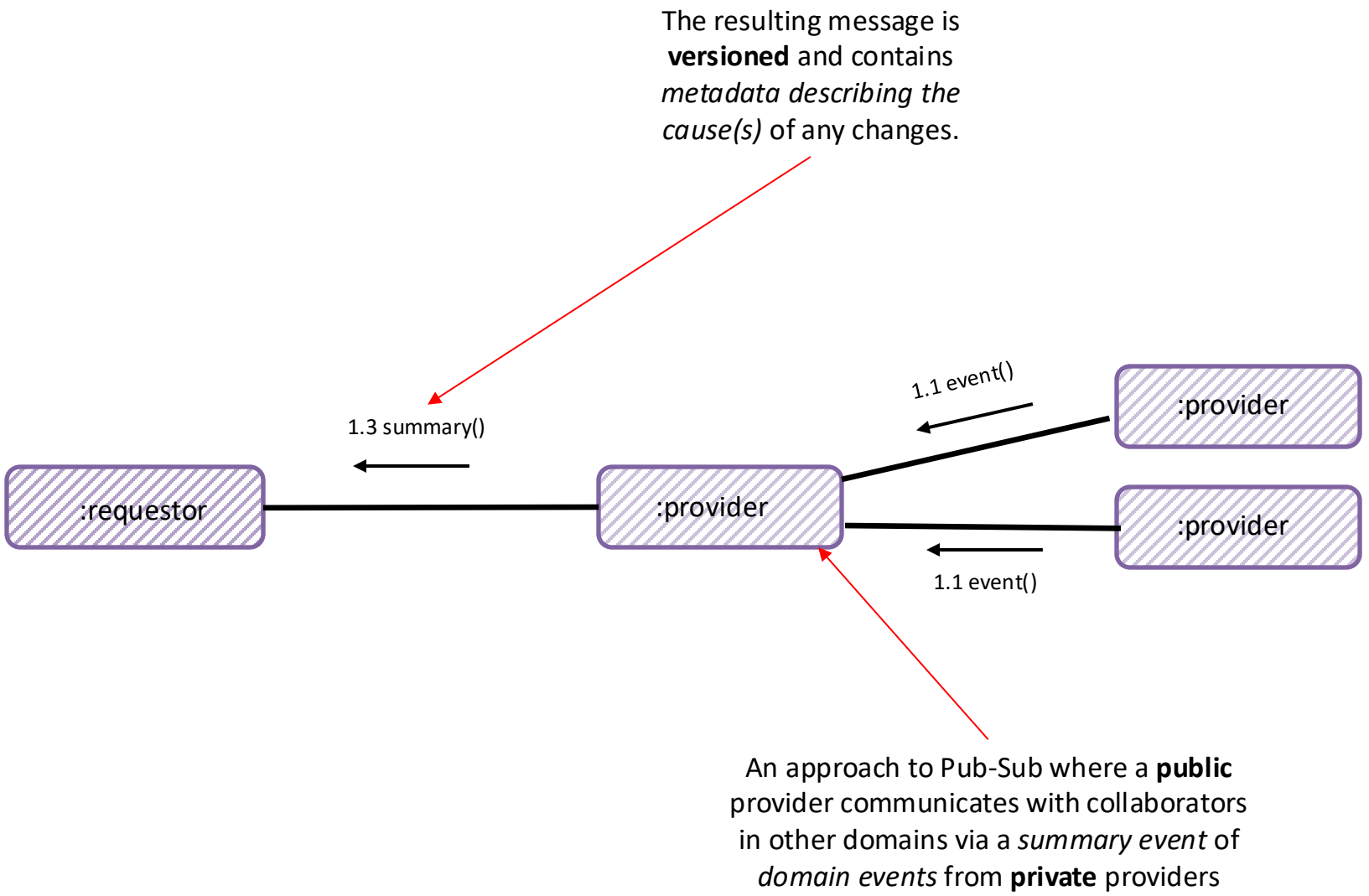
If Later, Queue



If later allows message to processed be out-of-order with a queue and competing consumers. A queue normally processes messages, and not events, so this only applied where we are using a queue.

If a message must be ordered, such as a series of commands, we must use requeue with delay, or a sequencer to re-order.

Public and Private Providers

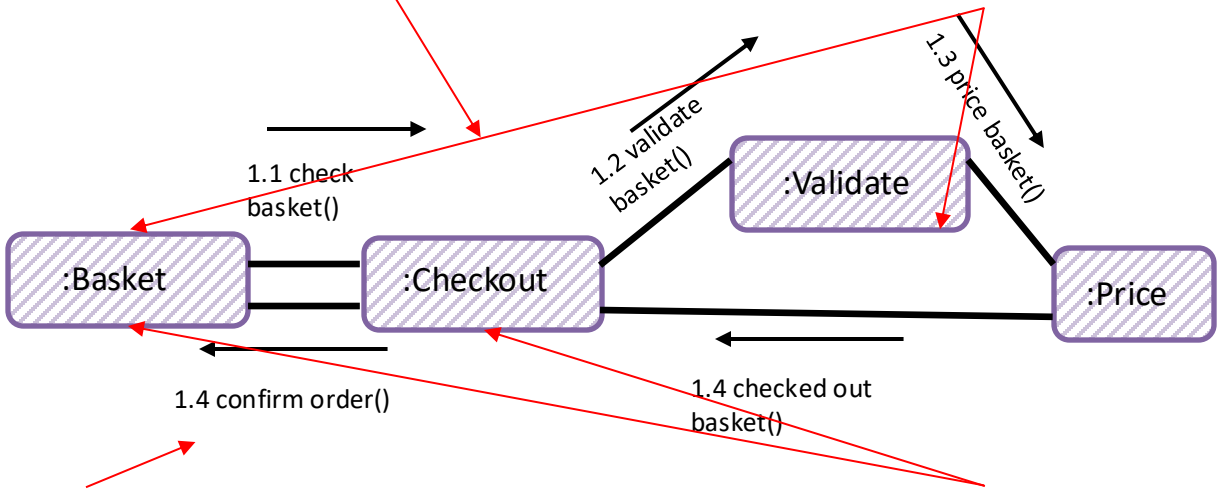


CONVERSATIONS

Conversations

Services are Processes
An ordering of activities with a beginning and end: it has inputs and outputs (outcome)

Lack of Distributed Transactions
Whilst 2PC is possible it is rarely used, how do we create an atomic workflow?



Command and Control
Who owns the process? Who informs us about its state? Who knows what step is next?

Coupling
Are we just coupled to data? Or are we coupled to behaviour?

Definitions

Conversation: when a component communicates with other components; may be a dialog (in-*, or out-*) or a monolog (in-only or out-only)

Workflow: literally the flow of work to achieve an outcome, partitioned into processes, which are in turn partitioned into activities, and again into tasks. A workflow may be implemented as one or more conversations between components.

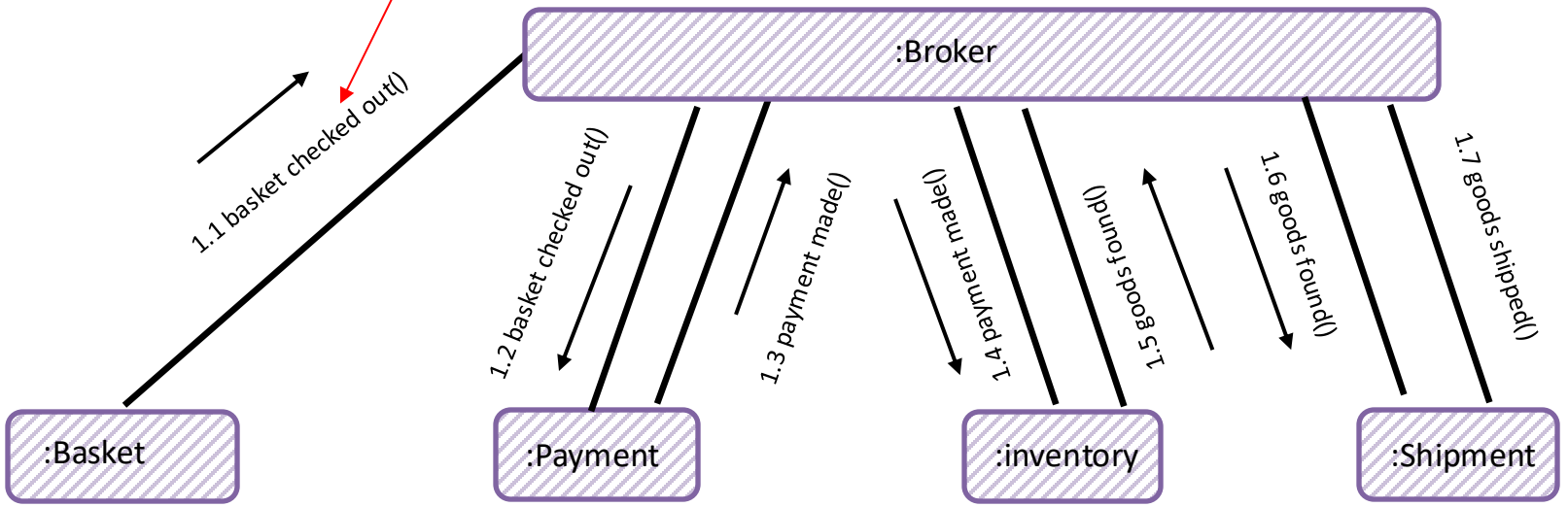
Choreography: a workflow where conversations are Out-only, and components listen for work to do from the bus. Loosely coupled, emergent behaviour.

Orchestration: a workflow where the conversation is directed. Authority may be distributed: each component knows who it talks to, or the message tells one component which step is next; or hub-and-spoke, a central controller talks to each component.

Saga: a workflow that offers an eventually consistent transaction. Each component updates their local state for the change; if one component cannot make the change then that component signals to other components to reverse the change. May be choreography or orchestration.

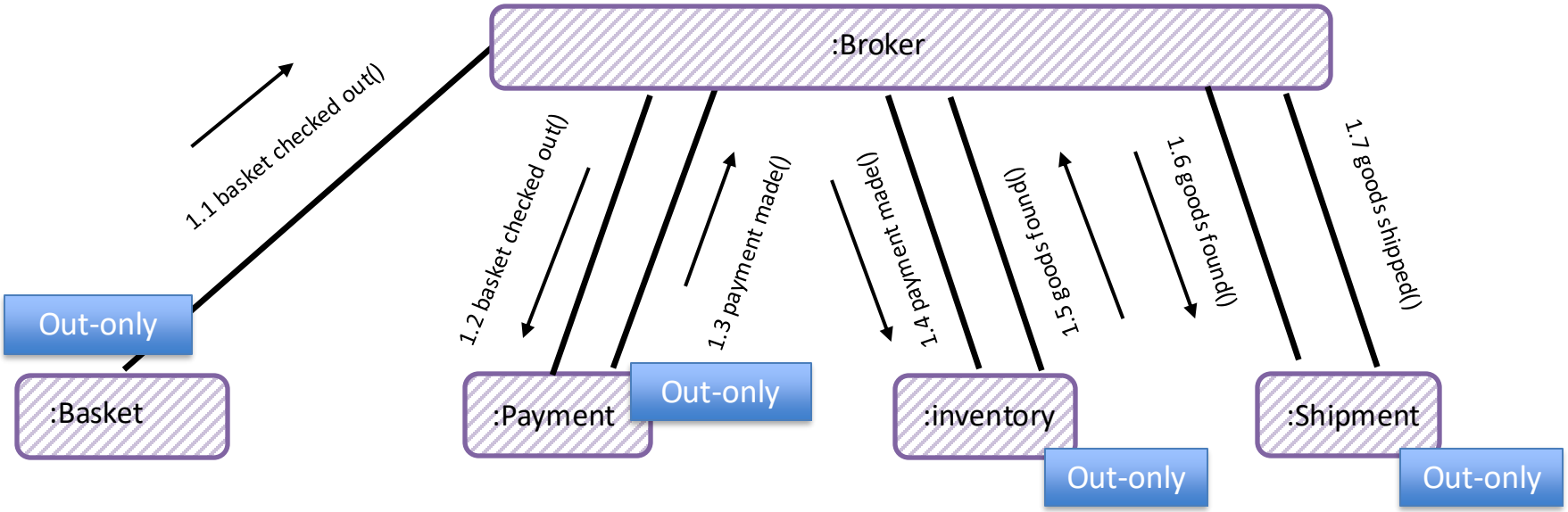
Choreography – Composing with Events

Events are Facts
Events tell us about the outcome of work flowing through a component



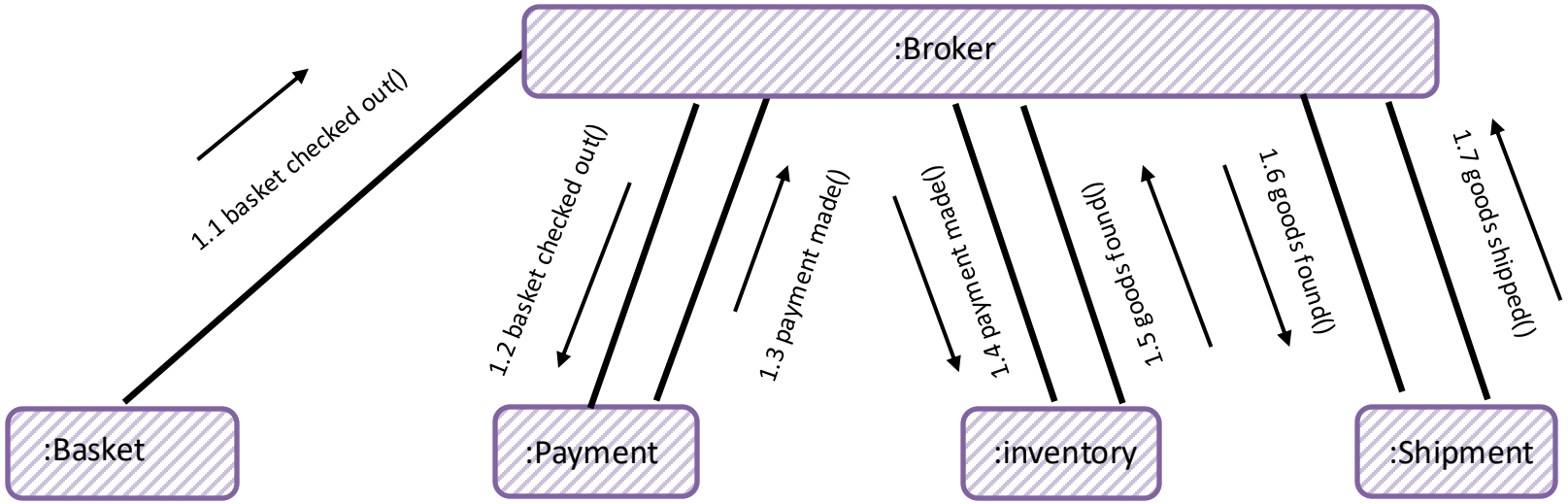
Loose Coupling: this is attractive because it is loosely coupled –components only know about the broker, and not about each other; this makes it easy to change who listens, add listeners etc. FAST to get started as teams have high independence!!!

Choreography – Composing with Events



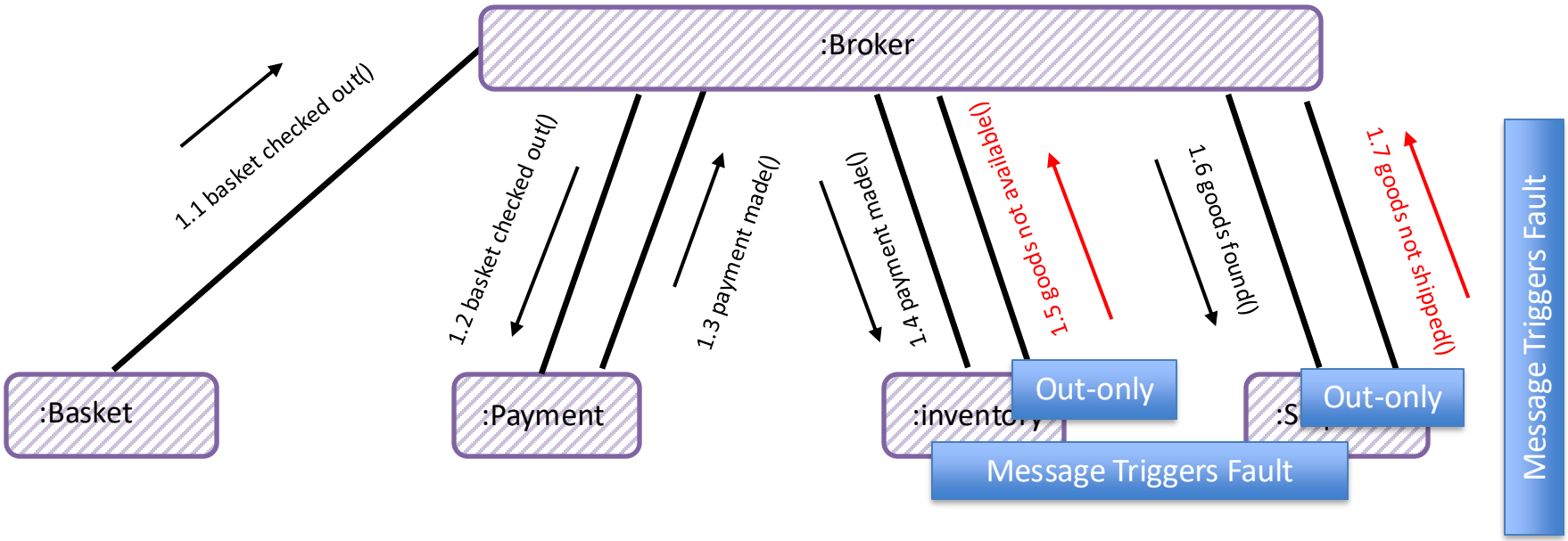
Event Chaining: to make an outcome happen, goods shipped, we rely on listeners existing who can trigger another action. This is known as event chaining – we chain events together for an outcome. The problem with event chaining is that we make it hard to see the flow – the **Pinball** anti-pattern: this is hard to reason about, observe, or diagnose.

Choreography – Saga (Eventing)



Saga: there is a business transaction, in this example: if picking or shipping fails, we need to refund the customer. The transaction requires each component in the event chain to succeed, or they must roll back. So we need to provide a saga over choreography.

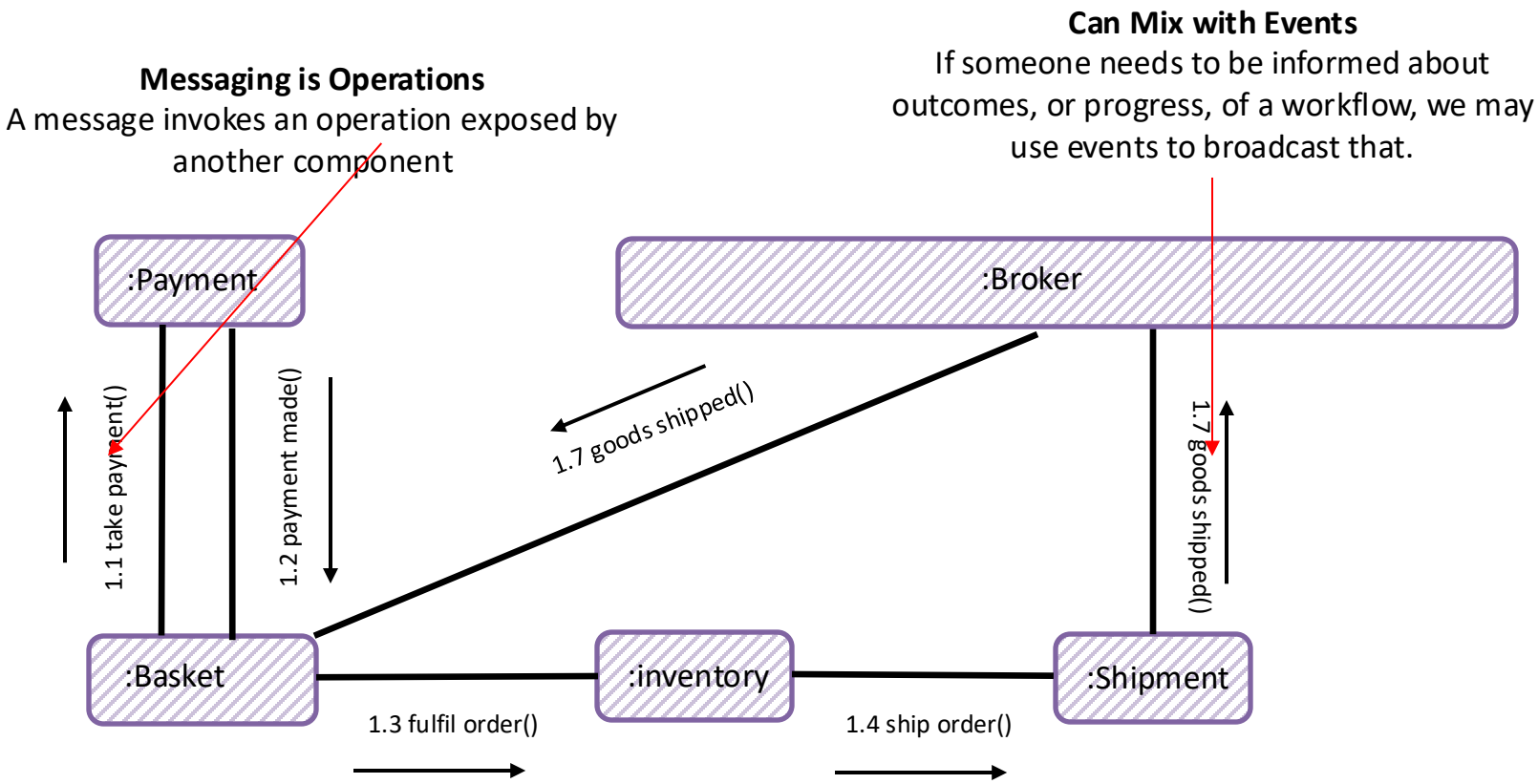
Choreography – Saga (Eventing)



Saga over Choreography: we use a **Fault Triggers Message** approach and raise an event if we fail. Each component that could fail, must offer Fault Triggers message. This fault is Out-only to preserve our choreography, and assumes upstream components will reverse in response.

Complexity: with propagation back up the chain, what happens if a chain step fails to reverse the transaction, due to error or state? We need to listen to failure events from any part of the chain, implying handling code for each provider. We may get emergent behaviour over order of reversal – goods not shipped needs to reverse both picking from the inventory and payment.

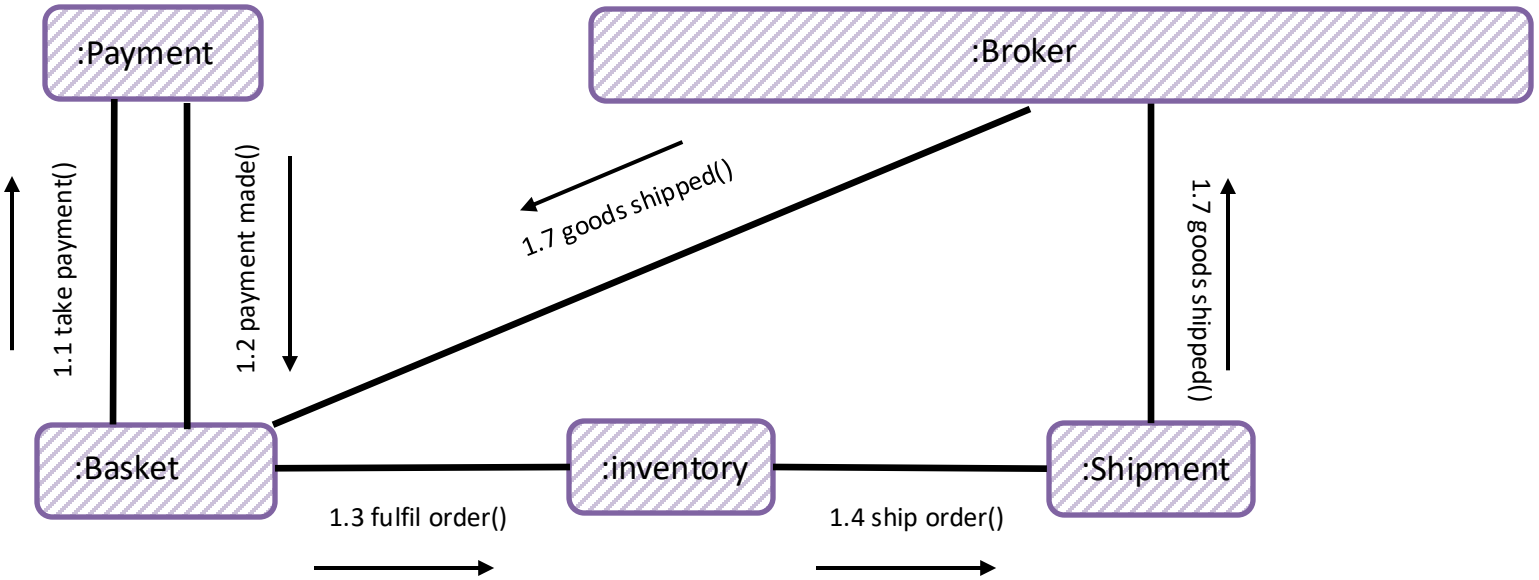
Orchestration – Composing with Messaging (Turn Taking)



Turn Taking: a component has a dialog with other components; each component knows how to run its part of the workflow – happy path and failure path; knowledge of the workflow is distributed among the actors.

Responsibility and Causality: this is attractive because we have causality – things happen in a known sequence and components clearly have responsibilities for carrying out actions within the flow.

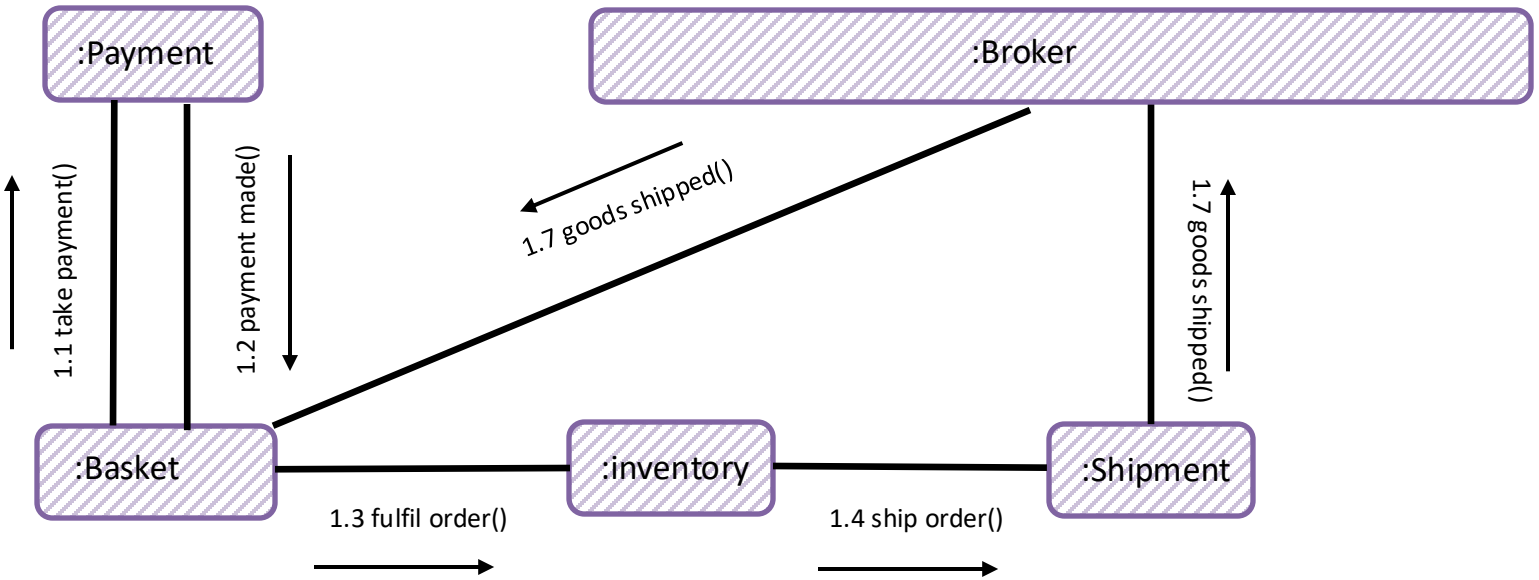
Orchestration – Composing with Messaging (Turn Taking)



Behavioural Coupling: There is coupling, we know about the provider we must call – and the workflow is distributed amongst the components; the trade-offs are simplicity (each component knows what it needs nothing else) and predictable as opposed to emergent behaviour (causality).

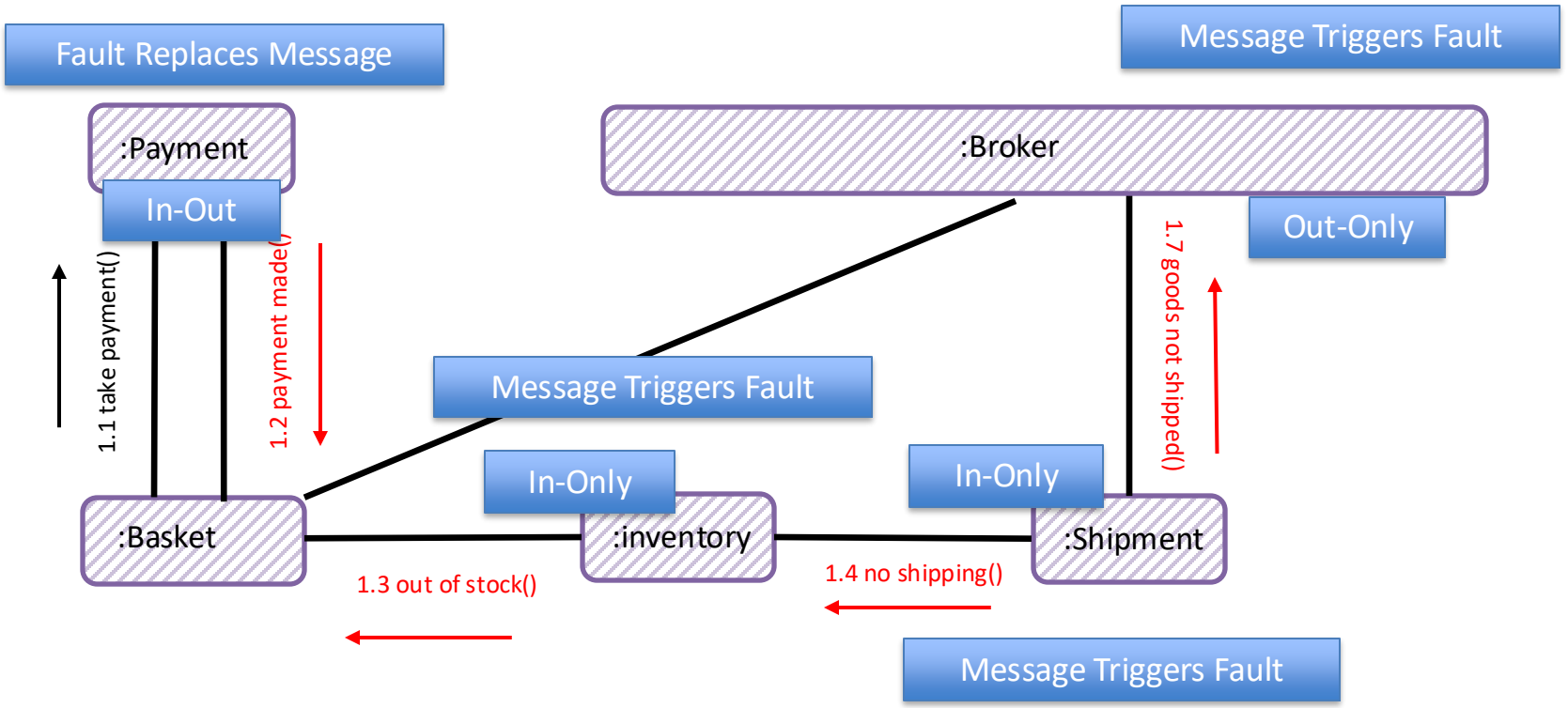
Coupling vs. Control: behavioural coupling is reduced to neighbours, but changing the workflow requires altering multiple components; no central control to understand flow

Orchestration – Saga (Turn Taking)



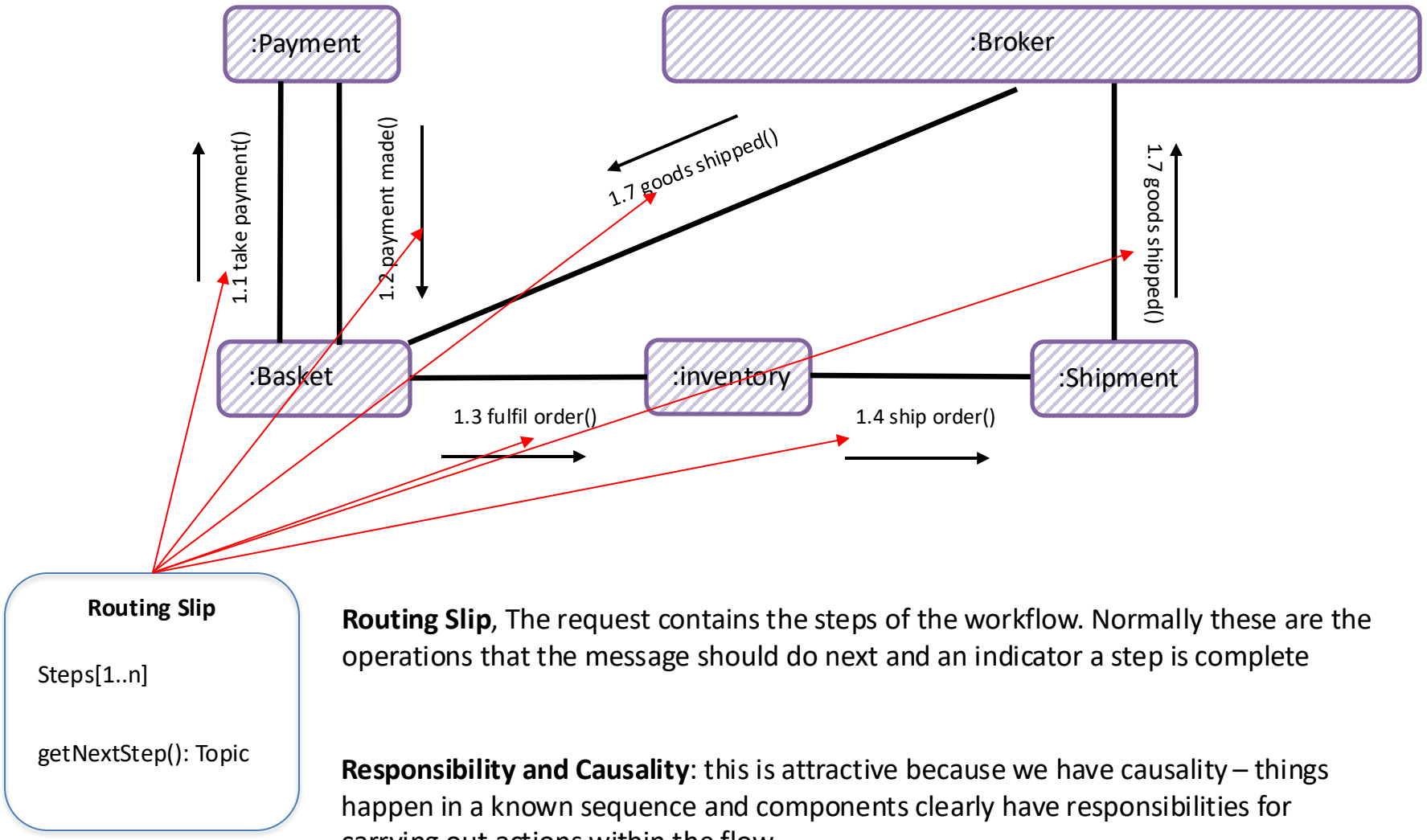
Saga: there is a business transaction, in this example: if picking or shipping fails, we need to refund the customer. The transaction requires that we roll back steps that have already been completed i.e. we reverse the flow.

Orchestration – Saga (Turn Taking)



Saga over Orchestration: with either Fault Triggers Message, or Fault Replaces Message, we can propagate errors back up the chain. This provides a simple model for flowing an error – I know how to deal with errors in the operation I invoked, and the chain reverses the operation.

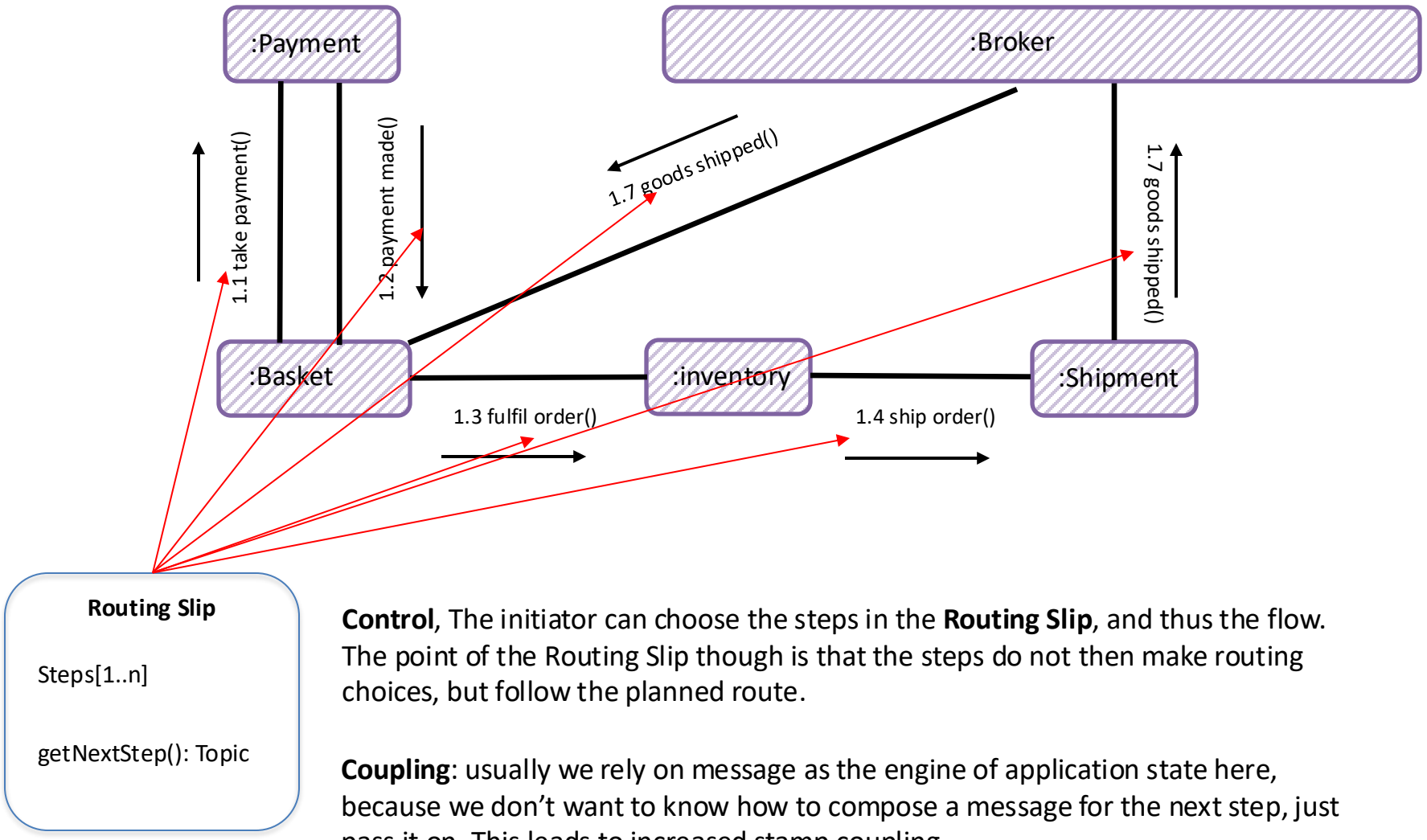
Orchestration – Composing with Messaging (Routing Slip)



Routing Slip, The request contains the steps of the workflow. Normally these are the operations that the message should do next and an indicator a step is complete

Responsibility and Causality: this is attractive because we have causality – things happen in a known sequence and components clearly have responsibilities for carrying out actions within the flow.

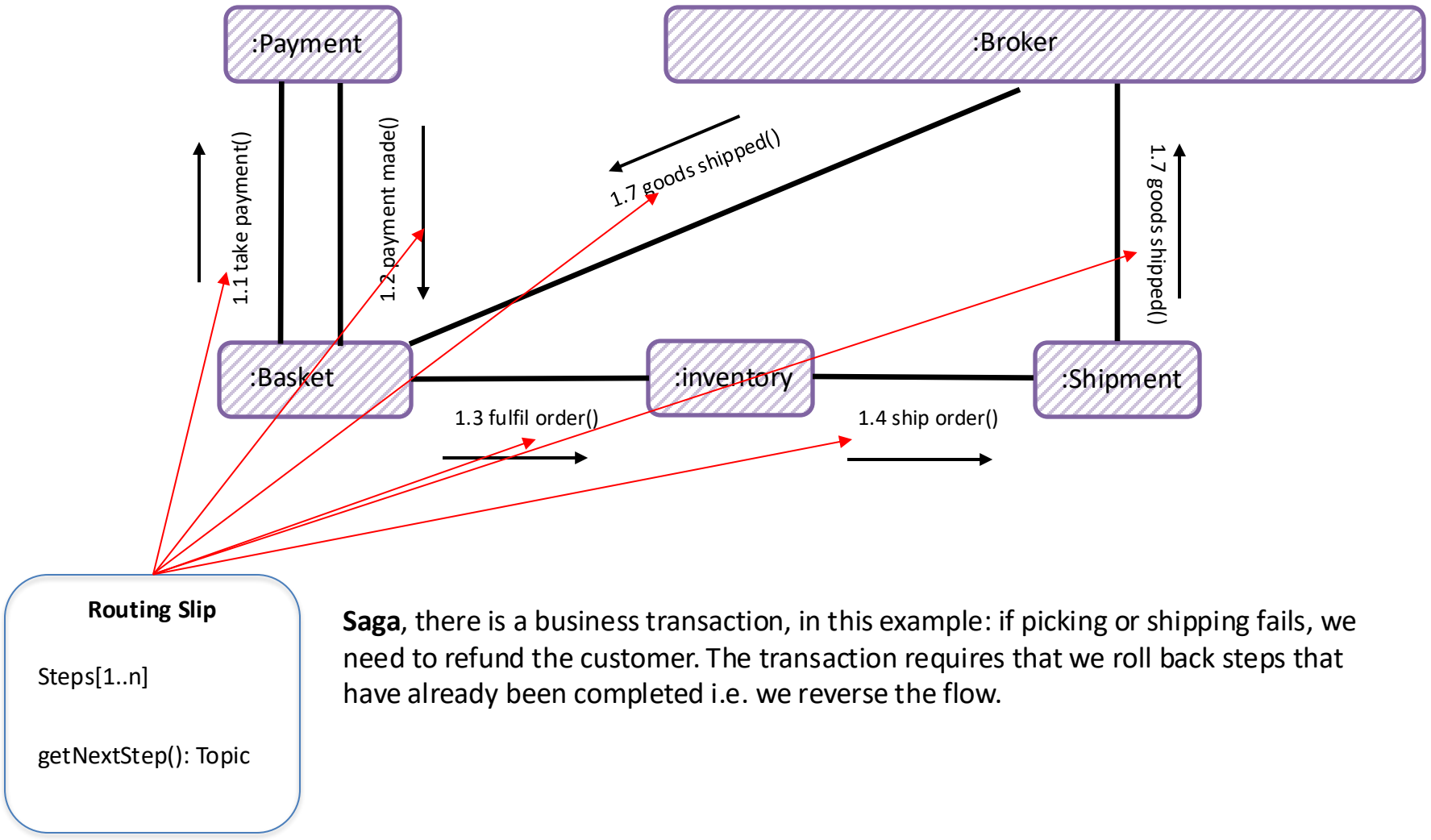
Orchestration – Composing with Messaging (Routing Slip)



Control, The initiator can choose the steps in the **Routing Slip**, and thus the flow. The point of the Routing Slip though is that the steps do not then make routing choices, but follow the planned route.

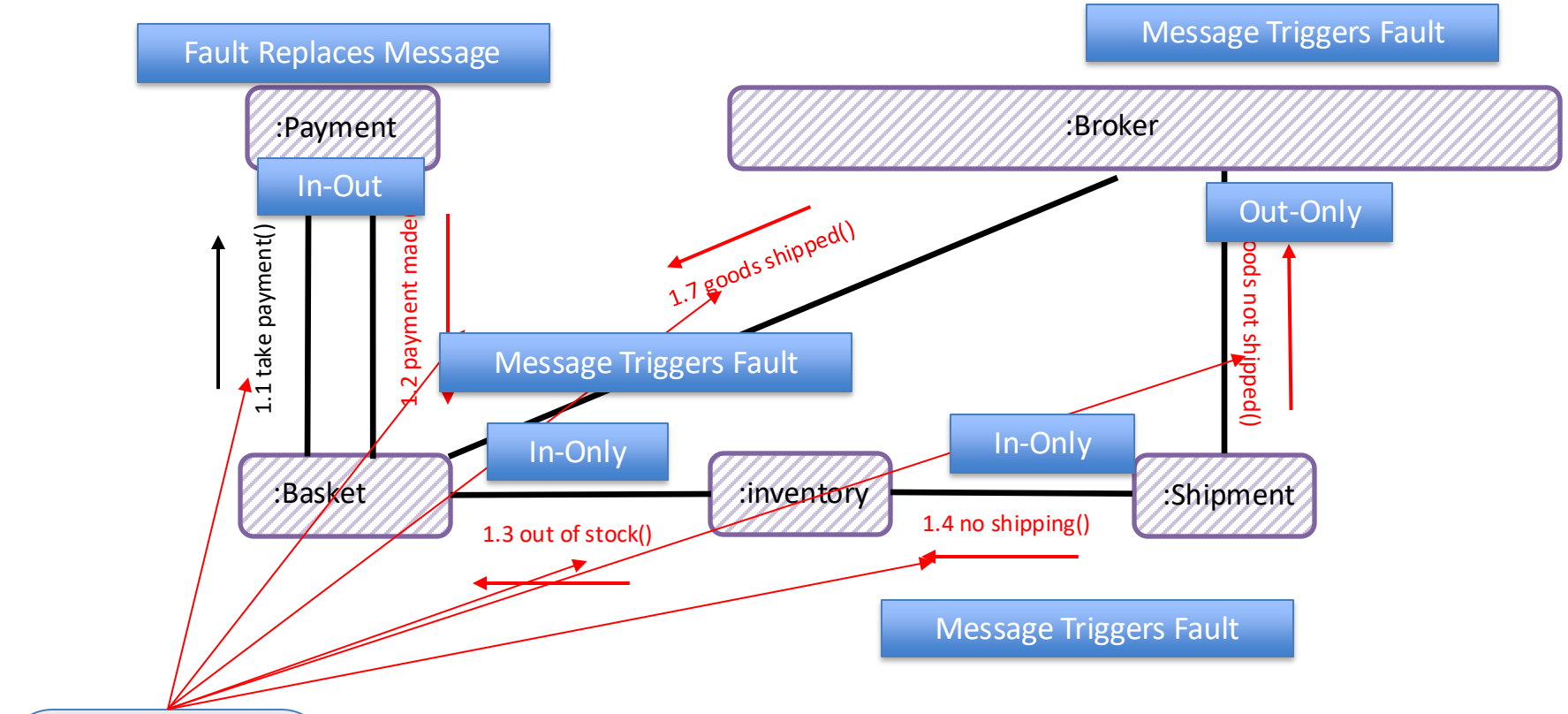
Coupling: usually we rely on message as the engine of application state here, because we don't want to know how to compose a message for the next step, just pass it on. This leads to increased stamp coupling

Orchestration – Saga (Routing Slip)



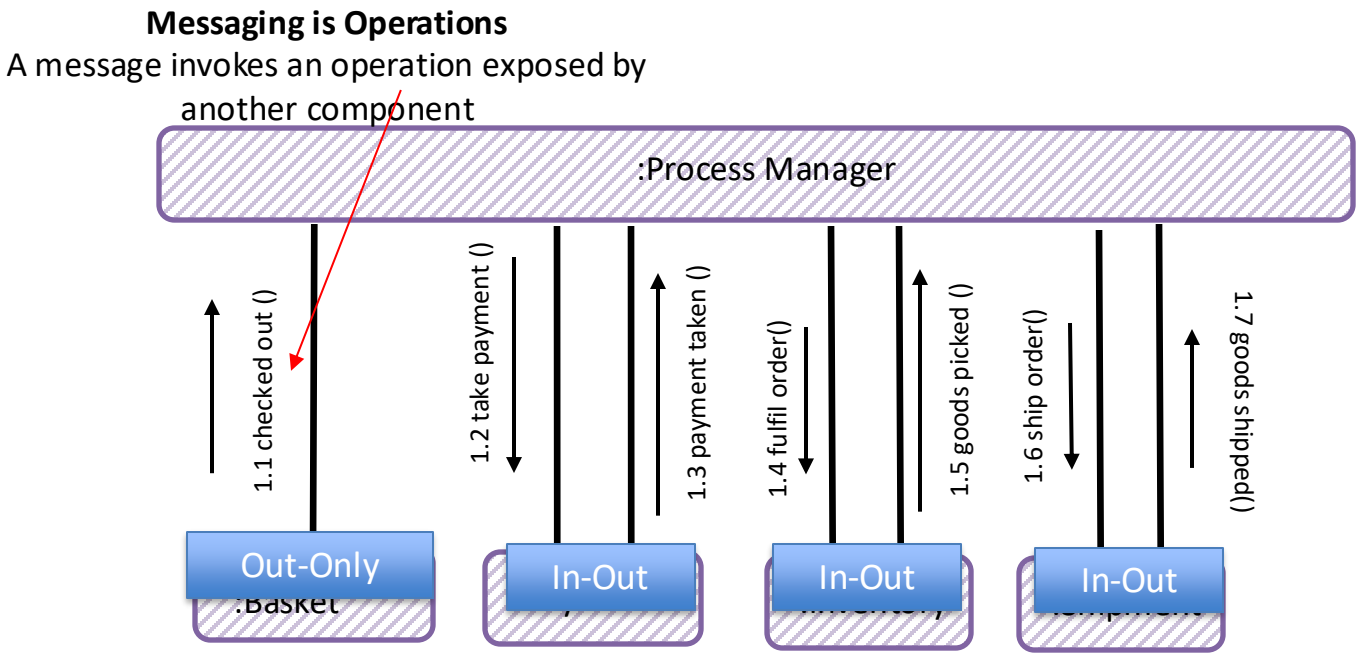
Saga, there is a business transaction, in this example: if picking or shipping fails, we need to refund the customer. The transaction requires that we roll back steps that have already been completed i.e. we reverse the flow.

Orchestration – Saga (Routing Slip)



Saga over Orchestration: with Fault Triggers Message, or Fault Replaces Message, we can propagate errors back up the chain. The error path is coded into the Routing Slip, for every step that could fail, there must be an error step to take next.

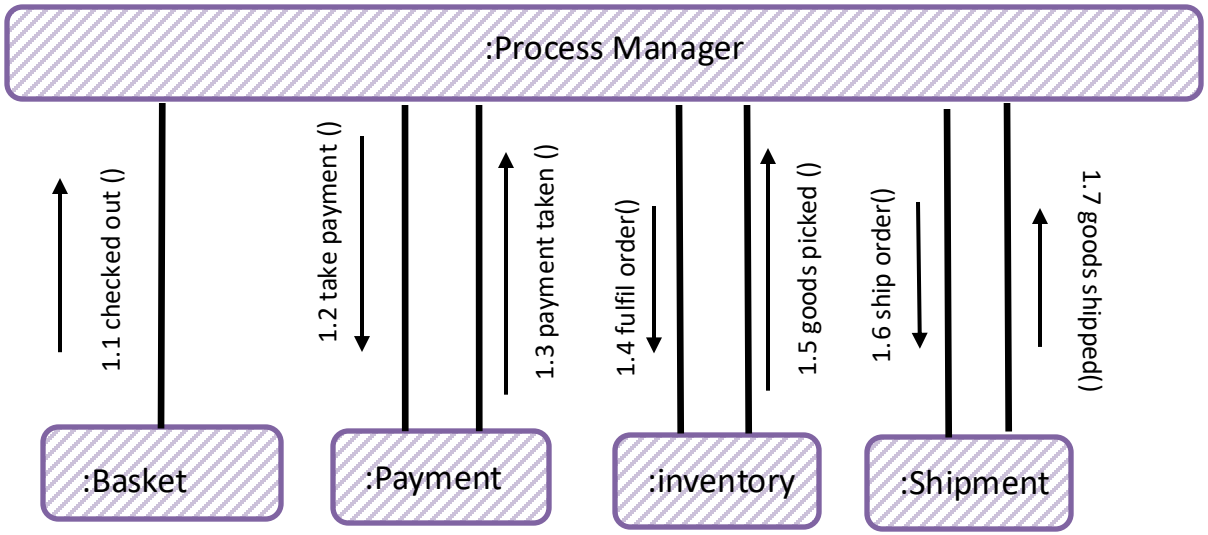
Orchestration – Composing with Messaging (Process Manager)



Process Manager: a component has a dialog with the process manager; knowledge of the workflow belongs to the process manager; each component responds to invocation of its operations

Responsibility and Causality: this is attractive because we have causality – things happen in a known sequence and components clearly have responsibilities for carrying out actions within the flow.

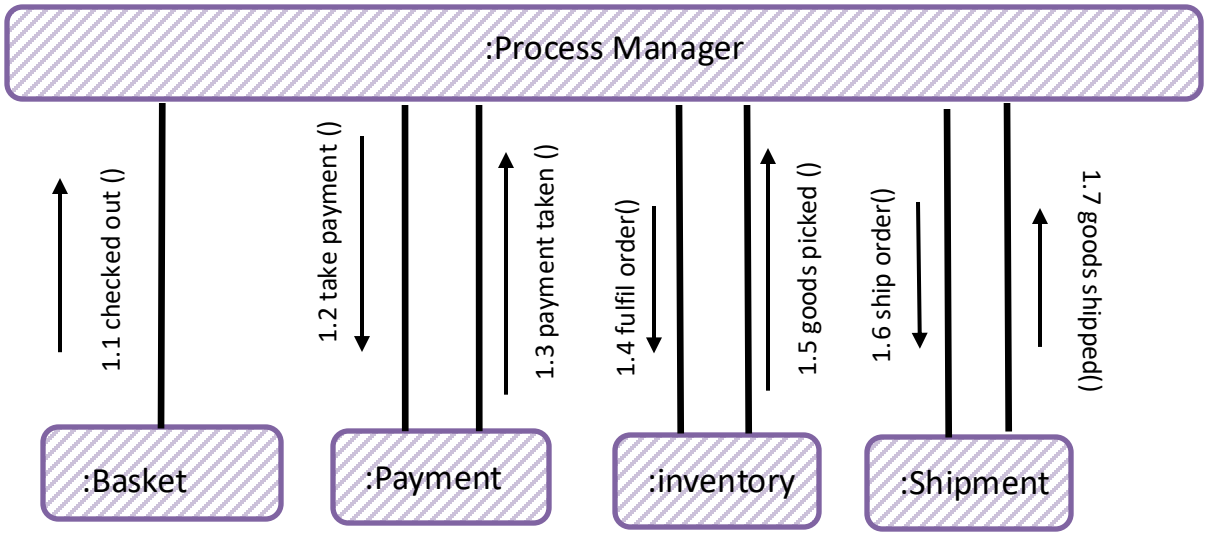
Orchestration – Composing with Messaging (Process Manager)



Coupling vs. Control: behavioural coupling is to the process manager, but changing the workflow requires jus altering it in the process manager; central control provides understanding of flow.

But understanding a component's roll in the flow, requires consulting the process manager, it is not local to the component.

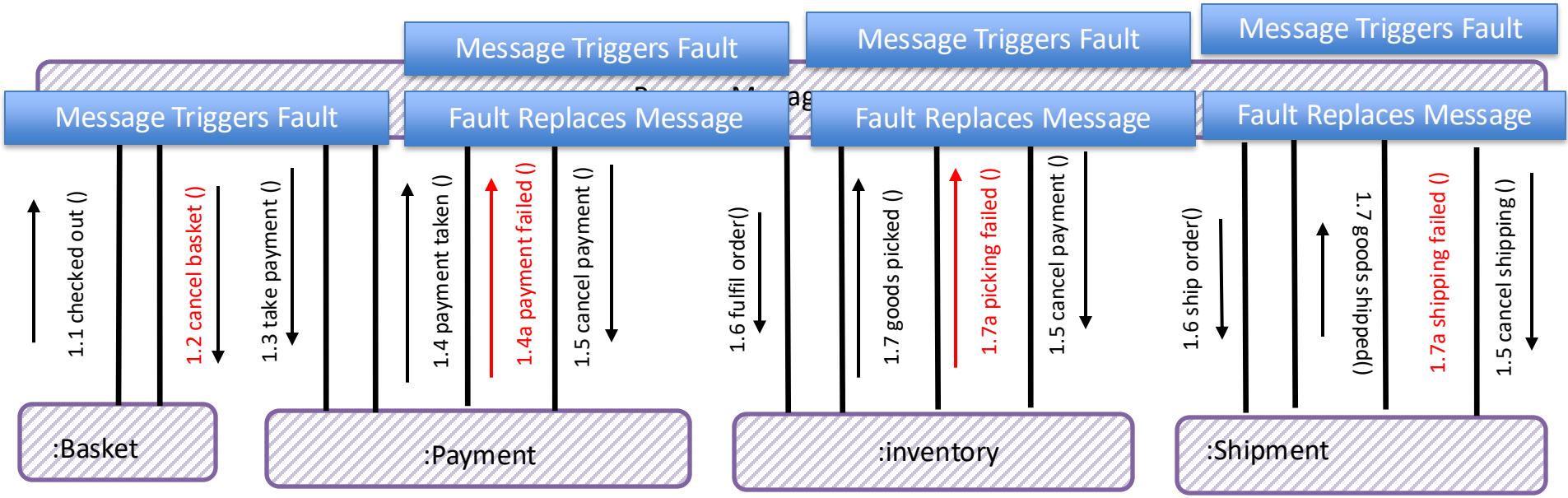
Orchestration – Saga (Process Manager)



Saga over Orchestration: there is a business transaction, in this example: if picking or shipping fails, we need to refund the customer; if shipping fails we need to return the goods to the warehouse. The transaction requires that we roll back steps that have already been completed i.e. we reverse the flow.

We notify the Process Manager, which now runs a workflow to unwind the workflow steps already taken (which it knows).

Orchestration – Saga (Process Manager)



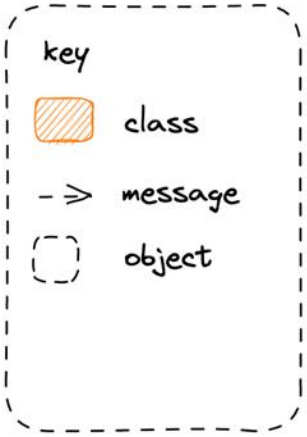
Transactions (Saga): uses Fault Replaces Message, to propagate errors back up to the bus, which triggers the error path on the flow, sending rollback messages. This provides a reliable model for flowing an error – I know that we will reverse the actions taken. It requires a set of operations on each component: raise error, respond to cancellation, but is less complex than choreography for multi-process flows.

Orchestration – Saga, Summary

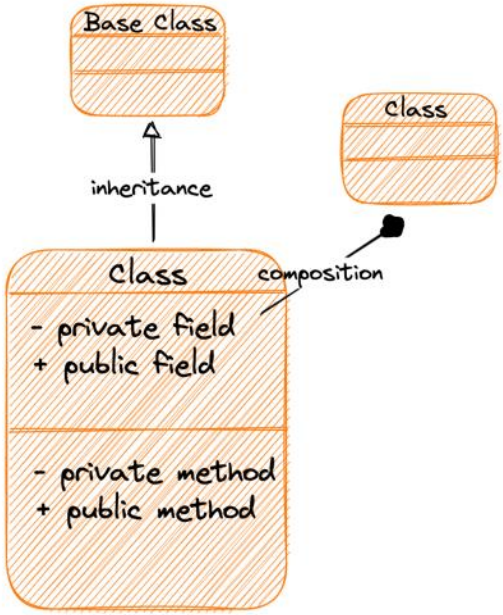
Turn Taking	**Routing Slip**	**Process Manager**
Complex Flow	Simple Flow	Complex Flow
Rigid Flow	Dynamic Flow	Dynamic Flow
No central point of failure	No central point of failure	Central point of failure
Distributed	Distributed	Hub-and-Spoke
No central administration or reporting	Central administration but not reporting	Central Administration and Reporting

Integrating using events

REACTIVE ARCHITECTURES



Object Orientation

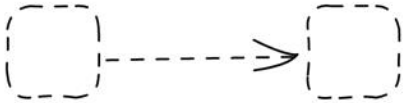


Data and Behaviour

A class couples data and the behaviour that depends upon that data. This allows encapsulation the data can be hidden and just behaviour exposed

Dynamic Dispatch

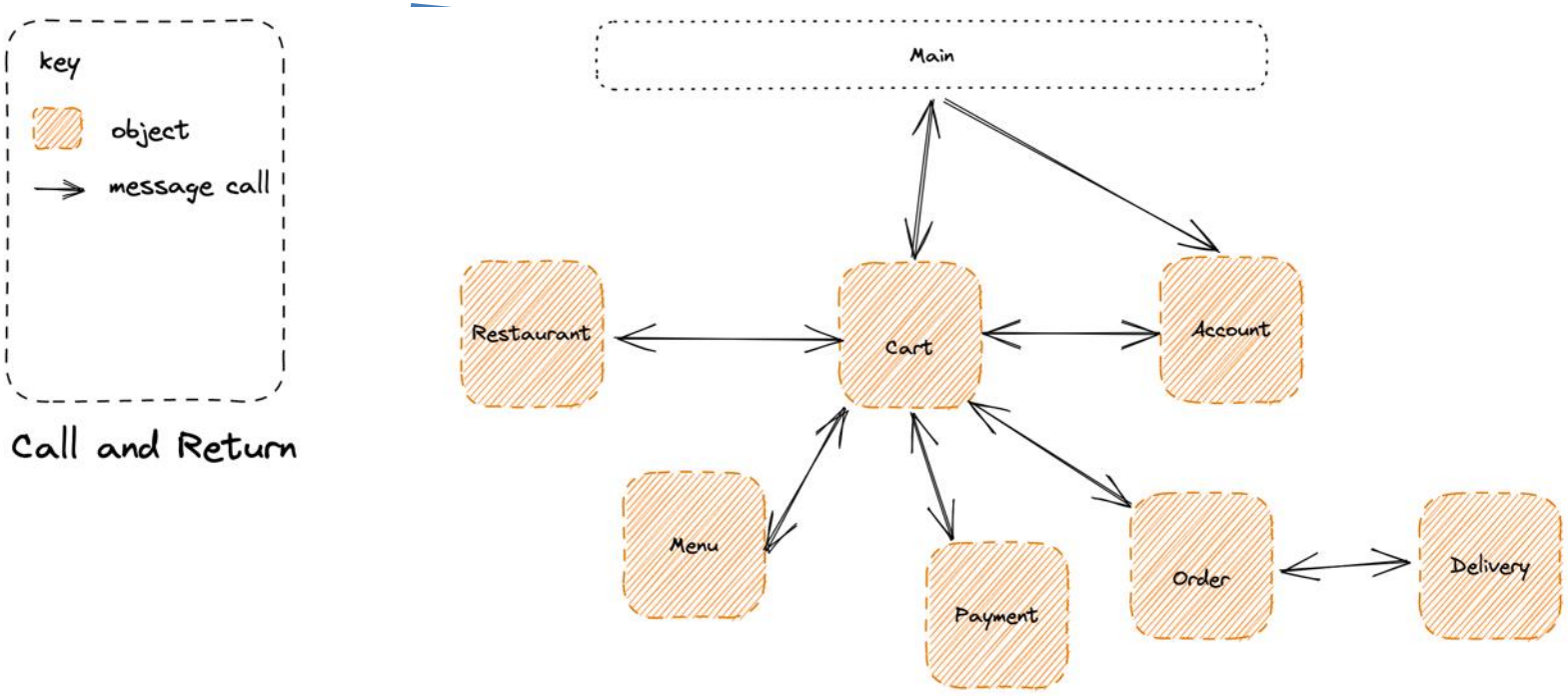
Due to inheritance the method chosen in response to a message may come from the base class of an object



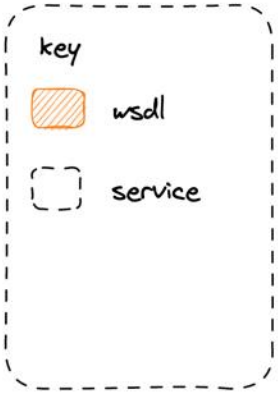
Message Passing

Objects communicate by message passing. A message is the method to call, and the parameters to that method.

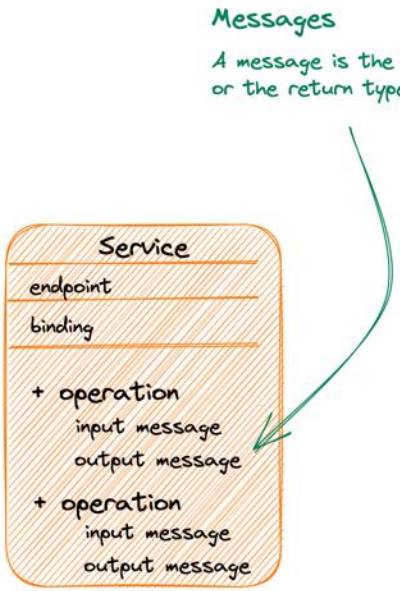
Call and Return: The main method represents our entry point and it uses message passing to invoke objects, which in turn invoke other objects, and return to their caller



God Object: A danger here is that we end up with a ”god” object, such as Cart here, that controls all the other objects. This is a high-degree of behavioral coupling



Service Orientation

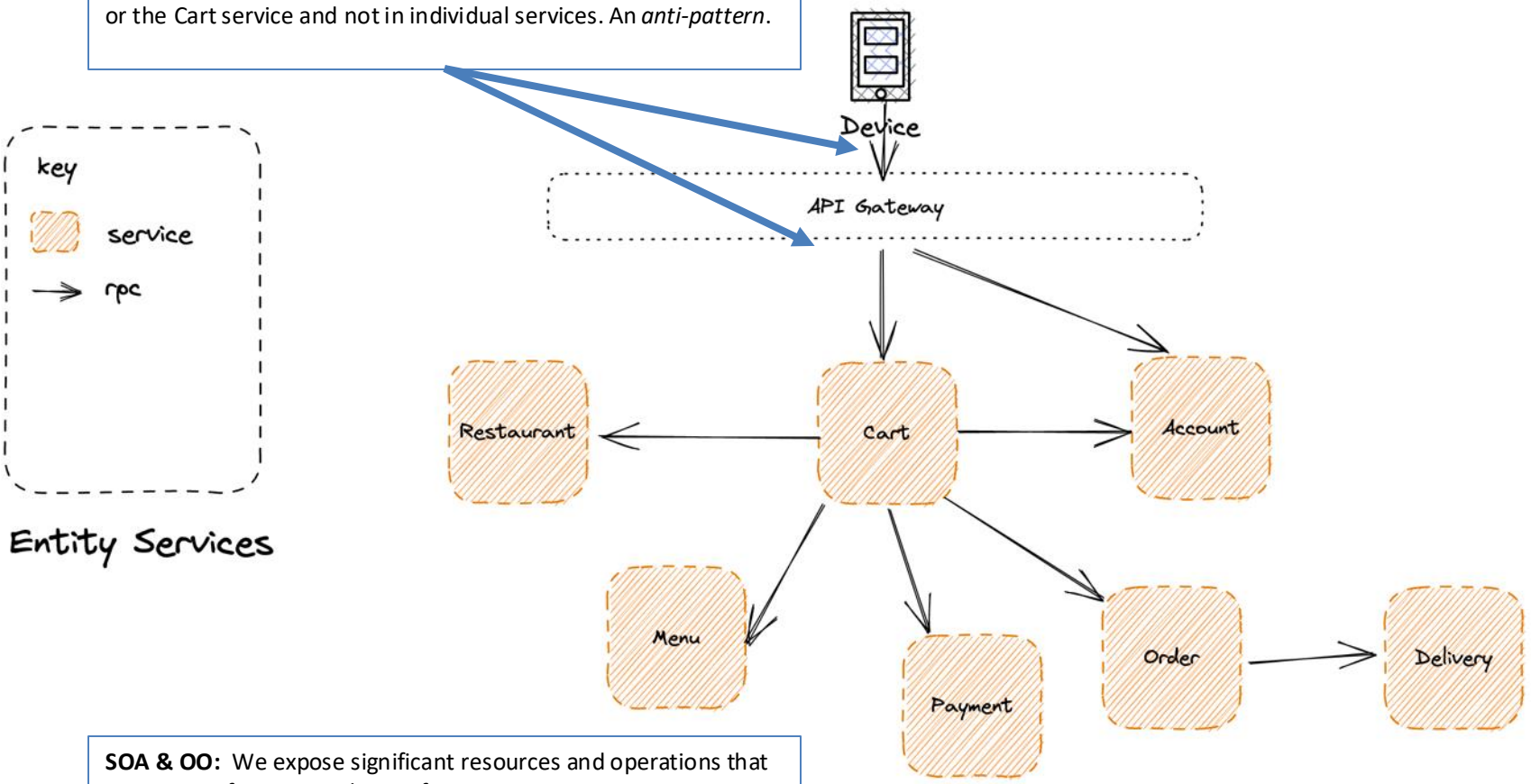


Data and Behaviour

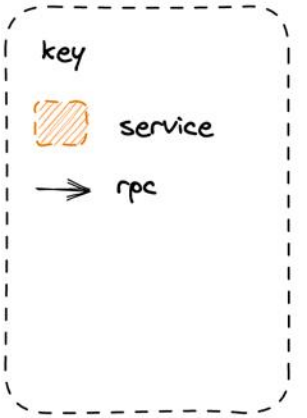
A service couples data and the behaviour that depends upon that data. This allows encapsulation the data can be hidden and just behaviour exposed

SOA & OO: SOA creates OO-like components, they encapsulate their data and expose behavior that is coupled to that data. This is the Web Services approach to services.

Feature Envy: Because domain logic needs to co-ordinate across these resources, it ends up either on the client, the API Gateway, or the Cart service and not in individual services. An *anti-pattern*.

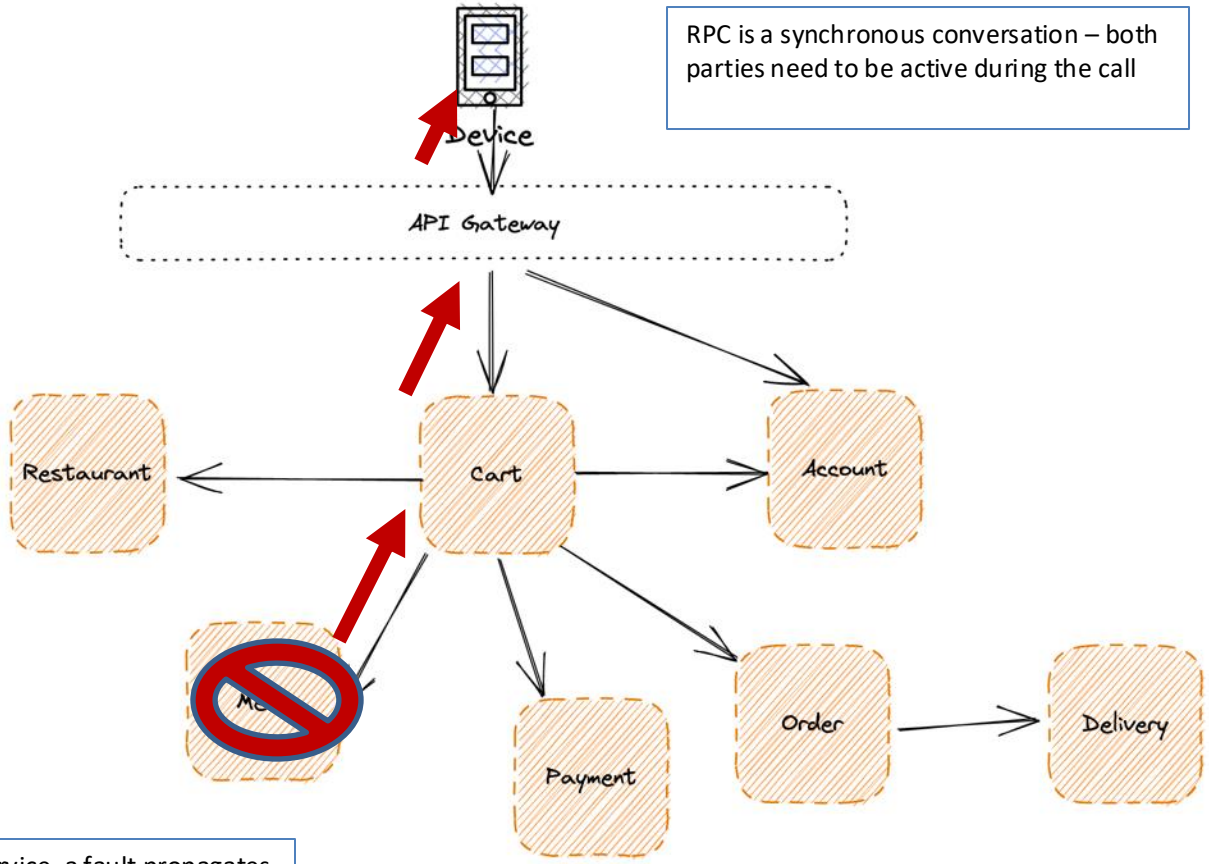


SOA & OO: We expose significant resources and operations that you can perform upon them, often CRUD.

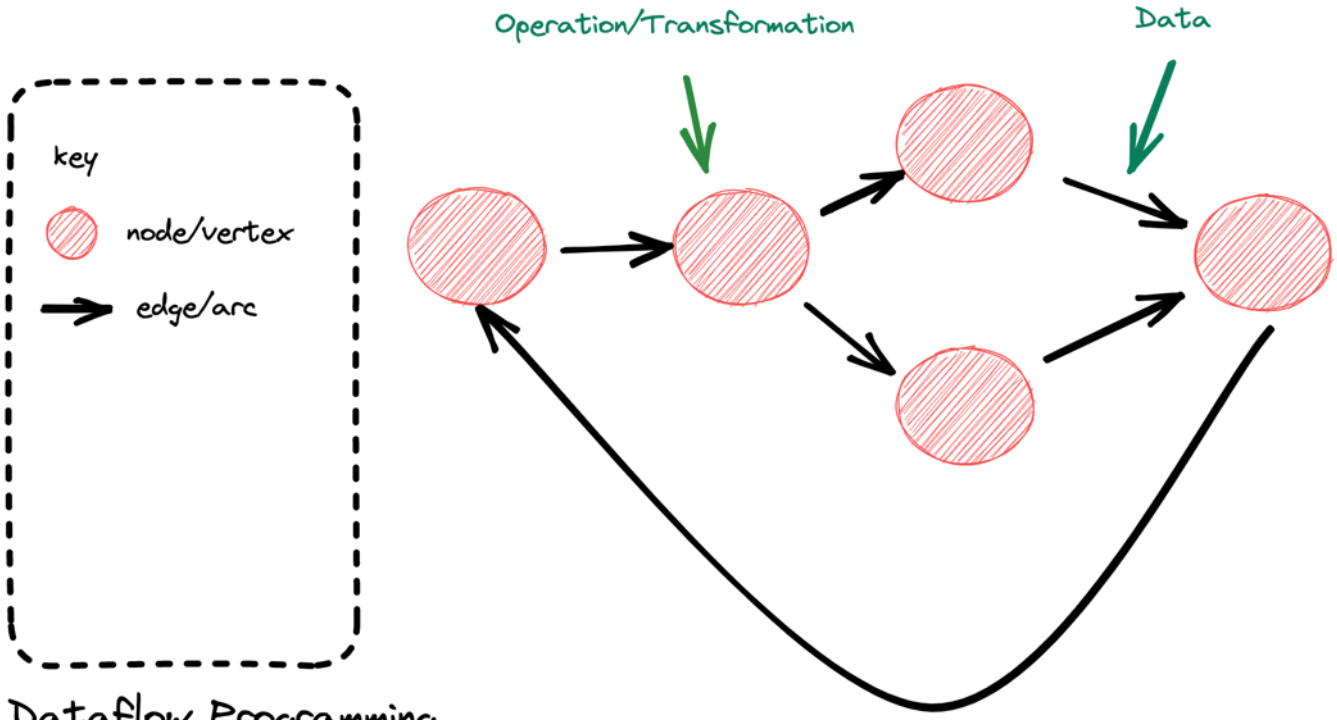


Entity Services

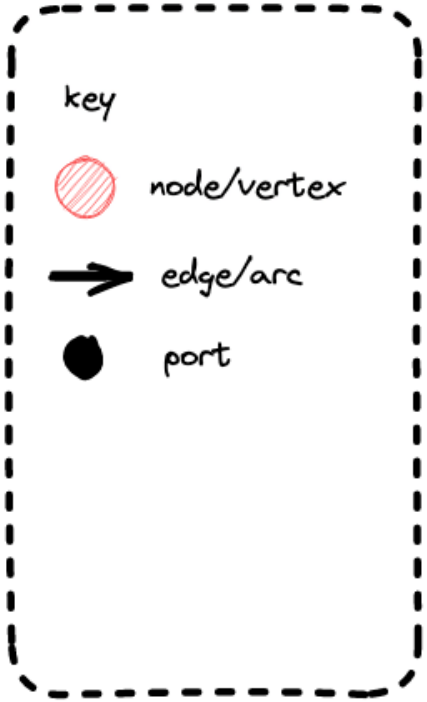
RPC is a synchronous conversation – both parties need to be active during the call

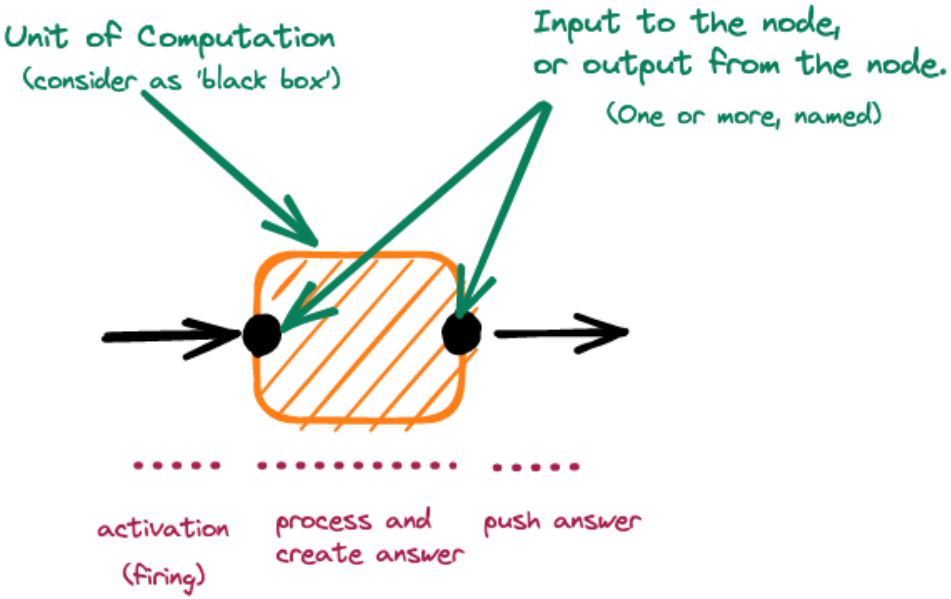


Faults Propagate: With a synchronous service, a fault propagates



Data Flow Programming conceptualizes a program as a directed graph where operations are represented as nodes which are connected via arcs through which data flows. A node performs an operation when input data is available.



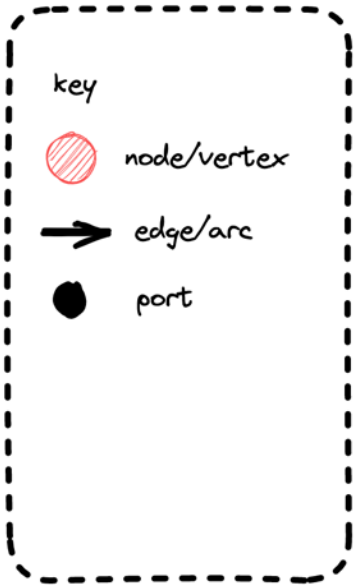


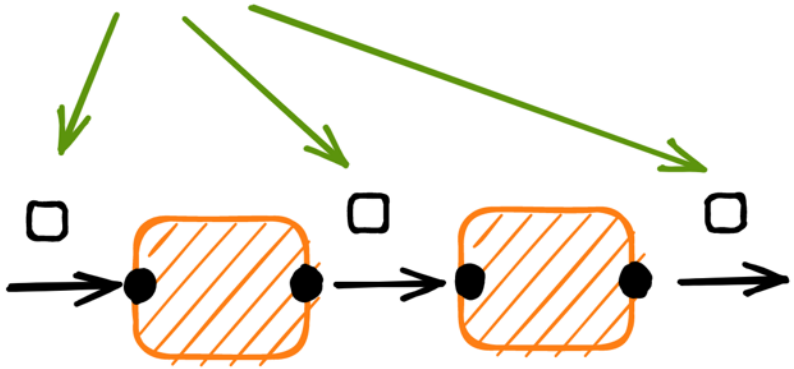
Dataflow Programming

Jack Dennis et al.

Data Packet

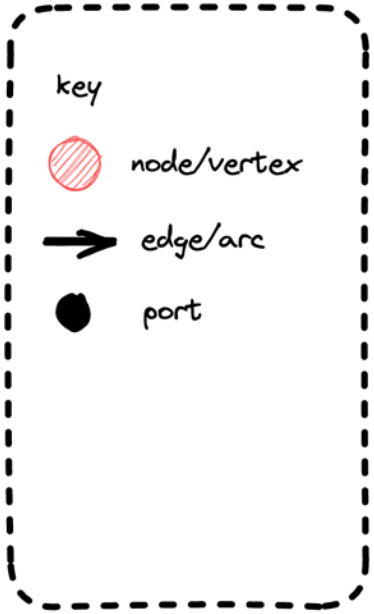
primitive/compound, structured/unstructured values, and even include other data packets

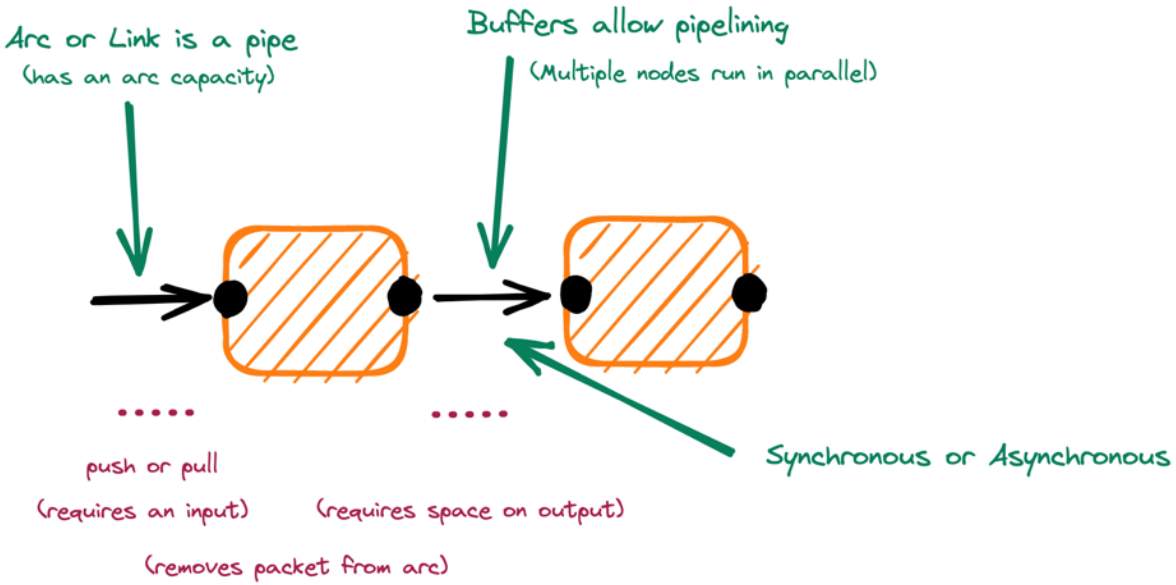




Dataflow Programming

Jack Dennis et al.





Dataflow Programming

Jack Dennis et al.

Node Lifetime: In 'classic' dataflow programming the lifetime of a node is from activation when there is work to do (push) or work is requested (pull) until it has pushed the answer.

Capacity: In dataflow programming we do not activate a node to read from the input, if there is no space on the output. (Infinite capacity links exist only in theory). This creates **backpressure**.

The Reactive Manifesto

Published in September 2014
Author(s): Jonas Bonér (Erik Meijer, Martin Odersky, Greg Young, Martin Thompson, Roland Kuhn, James Ward and Guillaume Bort)

Defines an architectural style: **Reactive Applications**

Write applications that:

react to events: their event-driven nature enables the following qualities

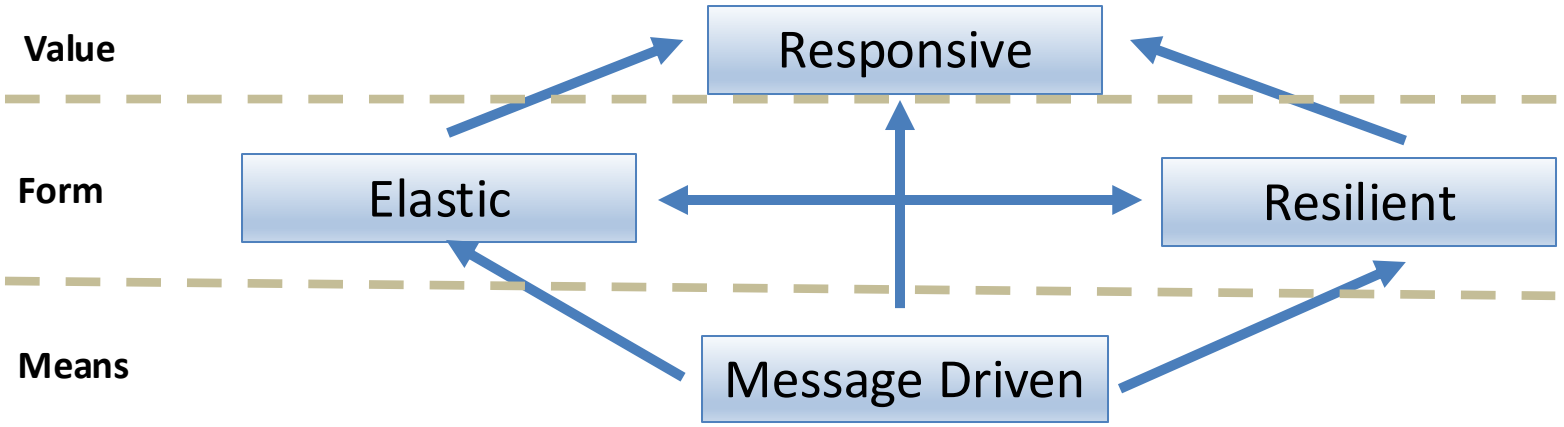
react to load: focus on scalability rather than single-user performance

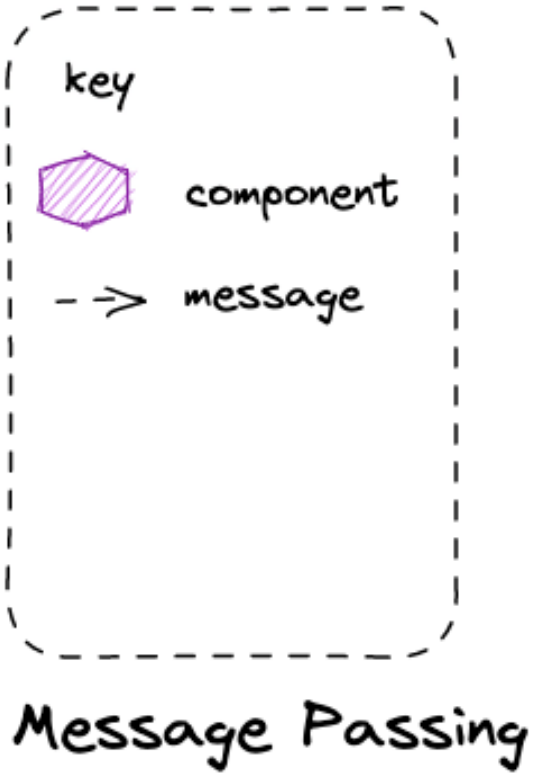
react to failure: resilient systems with the ability to recover at all levels

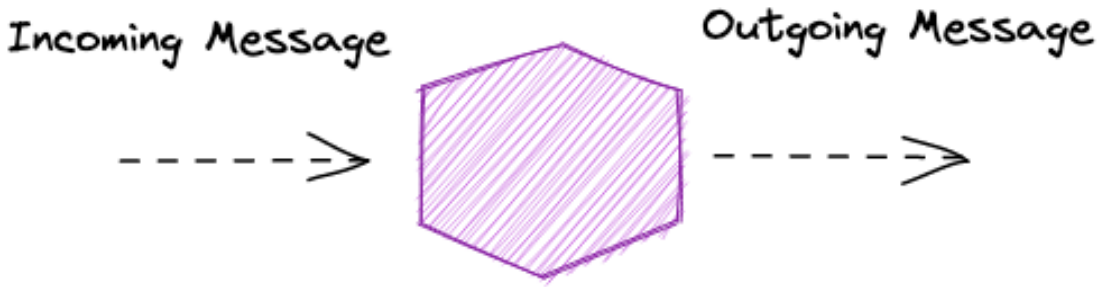
react to users: combine the above for an interactive user experience

Responsive: The system responds in a timely manner.
Resilient: The system stays responsive in the presence of failure.
Elastic: The system stays responsive under varying workload.
Message Driven: Rely on asynchronous message passing

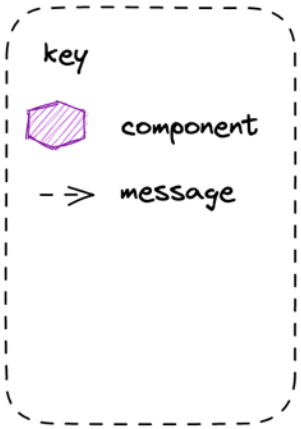
https://www.reactivemanifesto.org/


Value
Form
Means
Responsive
Elastic
Resilient
Message Driven

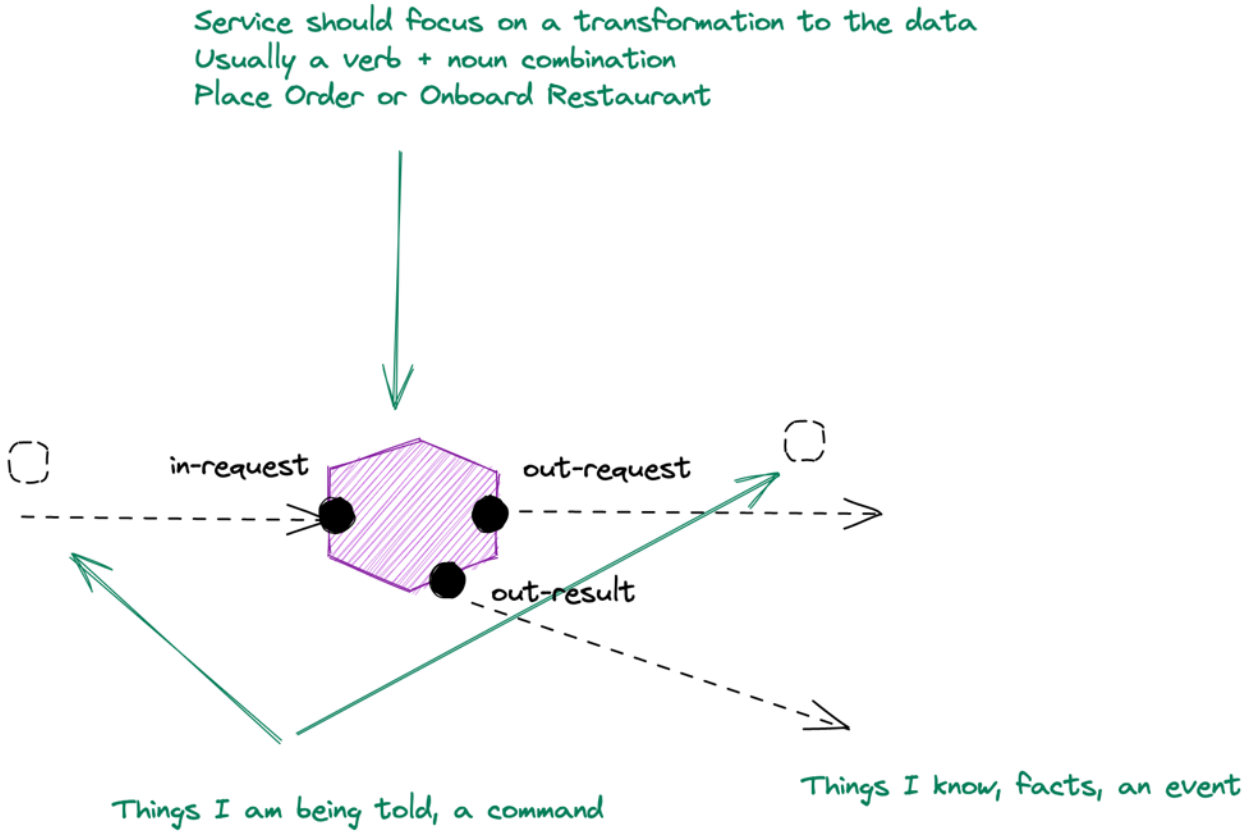




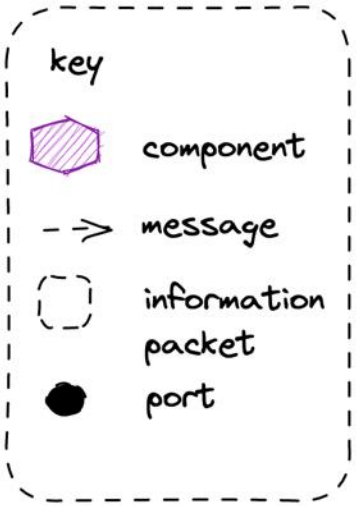
Message Passing is an asynchronous method of communication – both parties do not have to be simultaneously present for communication to occur, instead mail is delivered to 'mailbox' of some form for later retrieval.

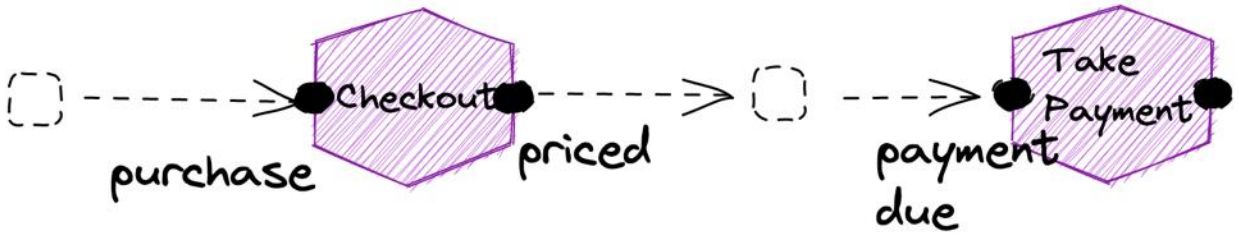


Message Passing

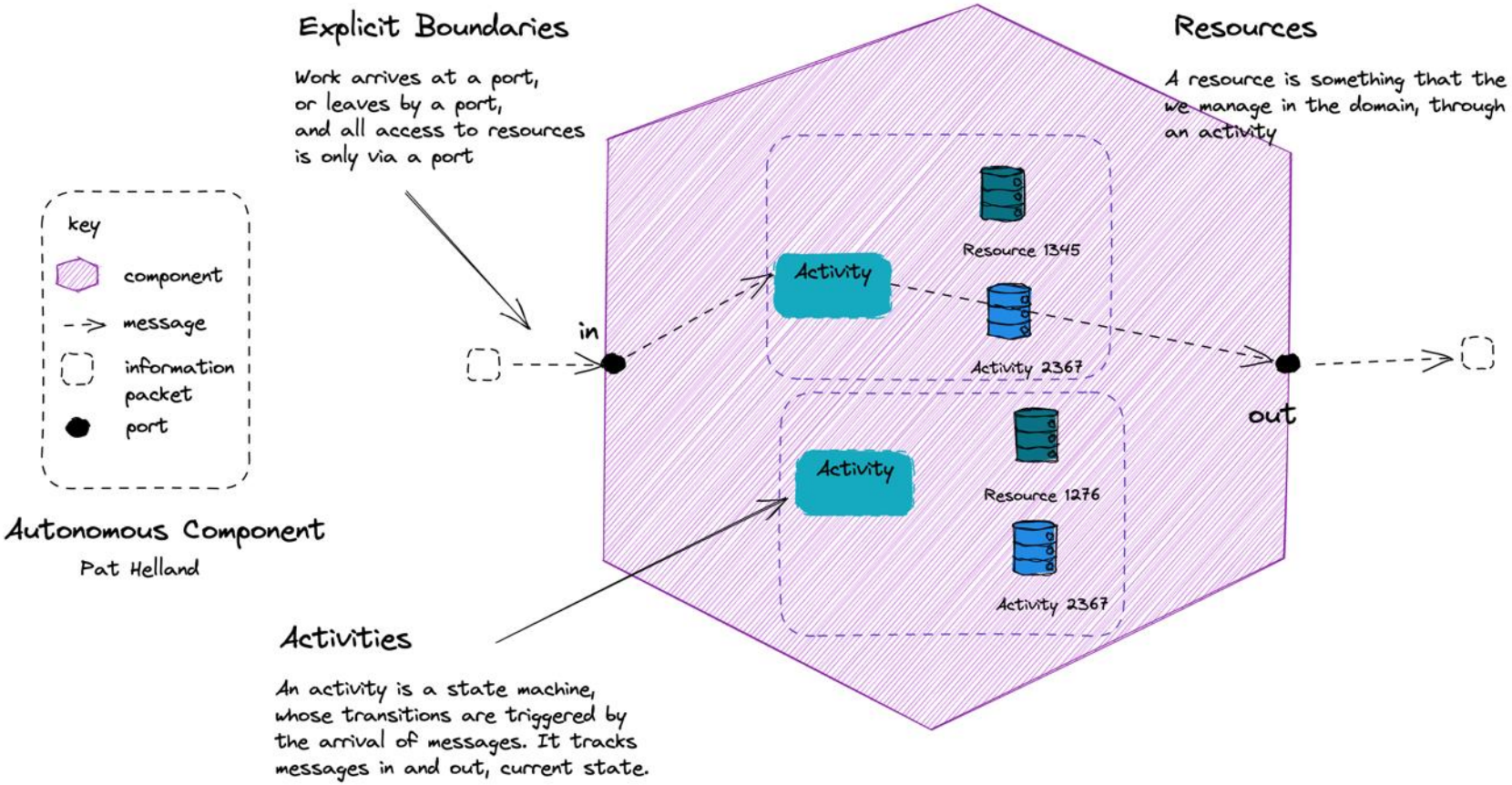


Coordinate Dataflow A reactive *principle* where we "orchestrate a continuous steady flow of information" focusing on division by behavior, not structure



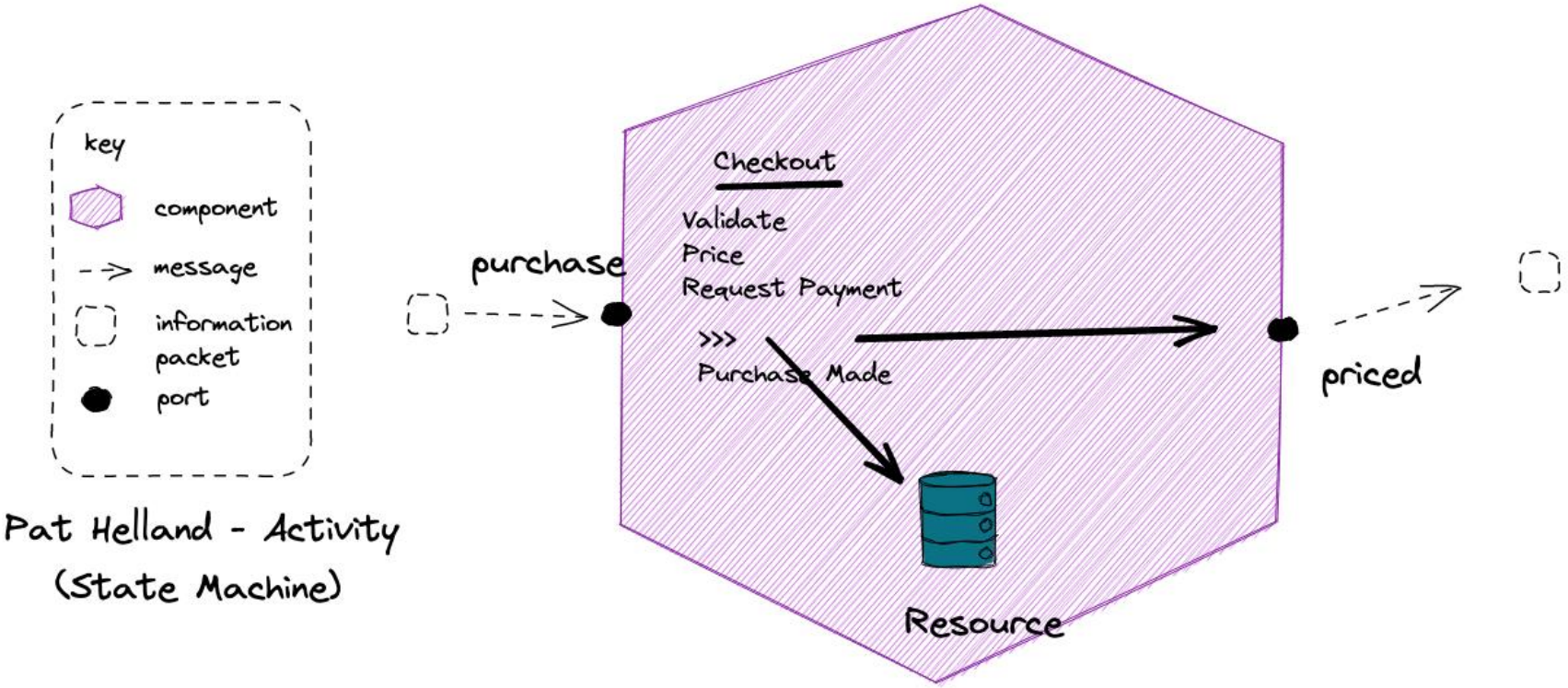


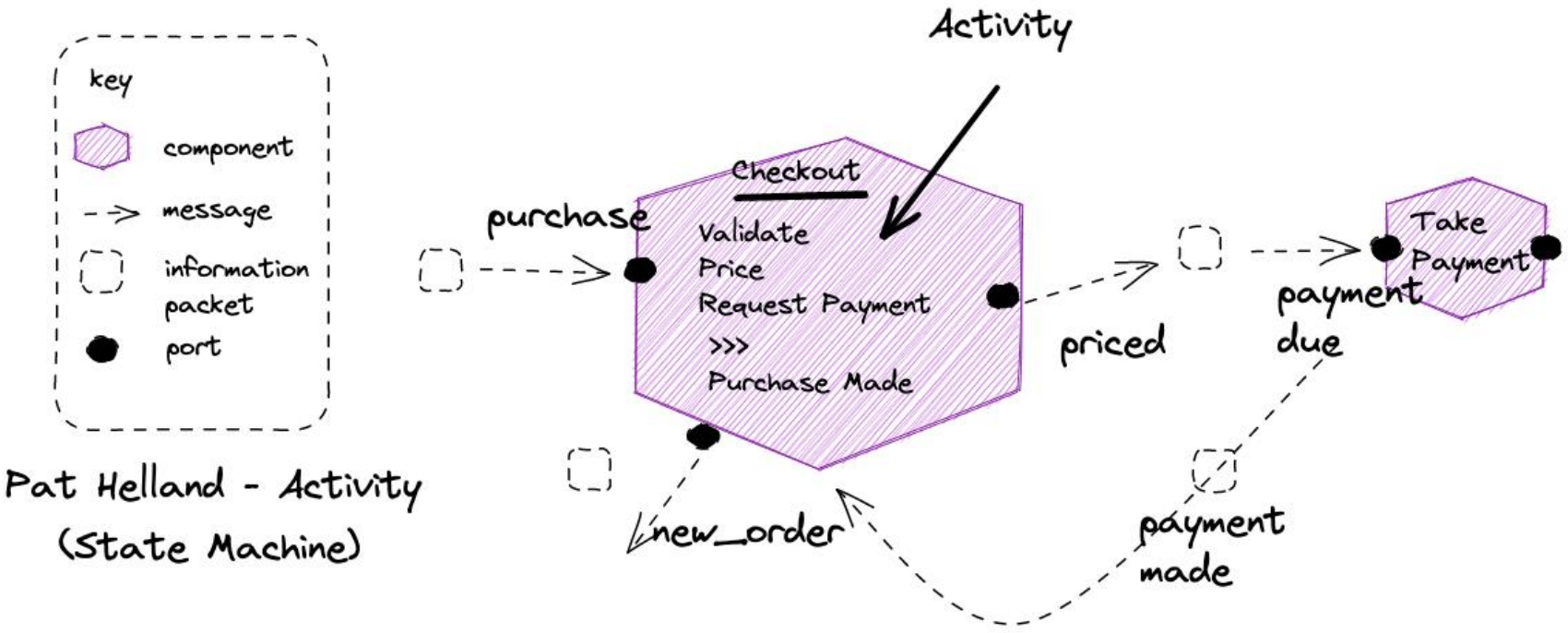
Partitioning Partition to take advantage of parallelism in the system, tasks that could be done concurrently with each other



Isolate Mutations A reactive *pattern* where we "contain and isolate mutable state". The mutable state lives within a component that has a defined boundary.

Assert Autonomy A reactive *principle* where we "by clearly defining the component boundaries, who owns what data and how the owners make it available"


key
component
message
information packet
port
Pat Helland - Activity (State Machine)
purchase
Checkout
Validate
Price
Request Payment
>>>
Purchase Made
priced
Resource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Pat Helland - Activity (State Machine)
Activity
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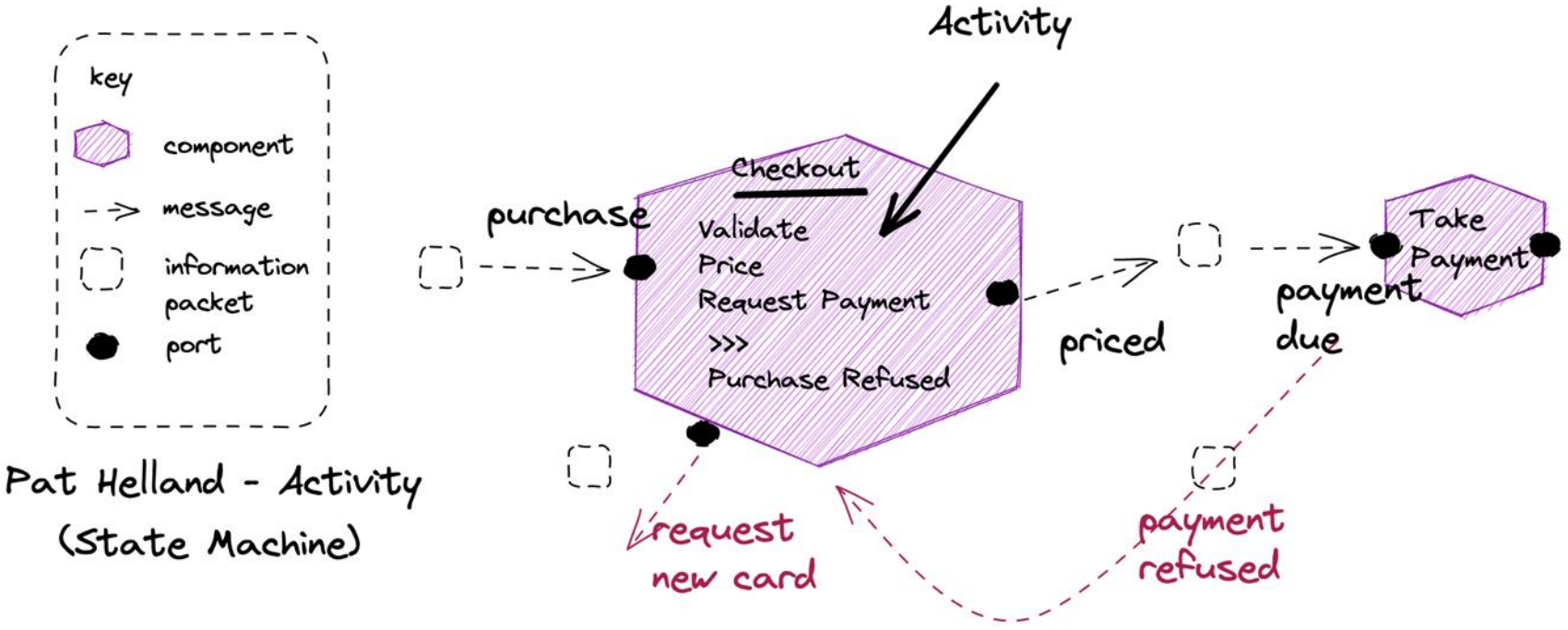
purchase
Validate
Price
Request Payment
>>>
Purchase Made
priced
payment due
Take Payment
new_order
payment made


key
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Price
Request Payment
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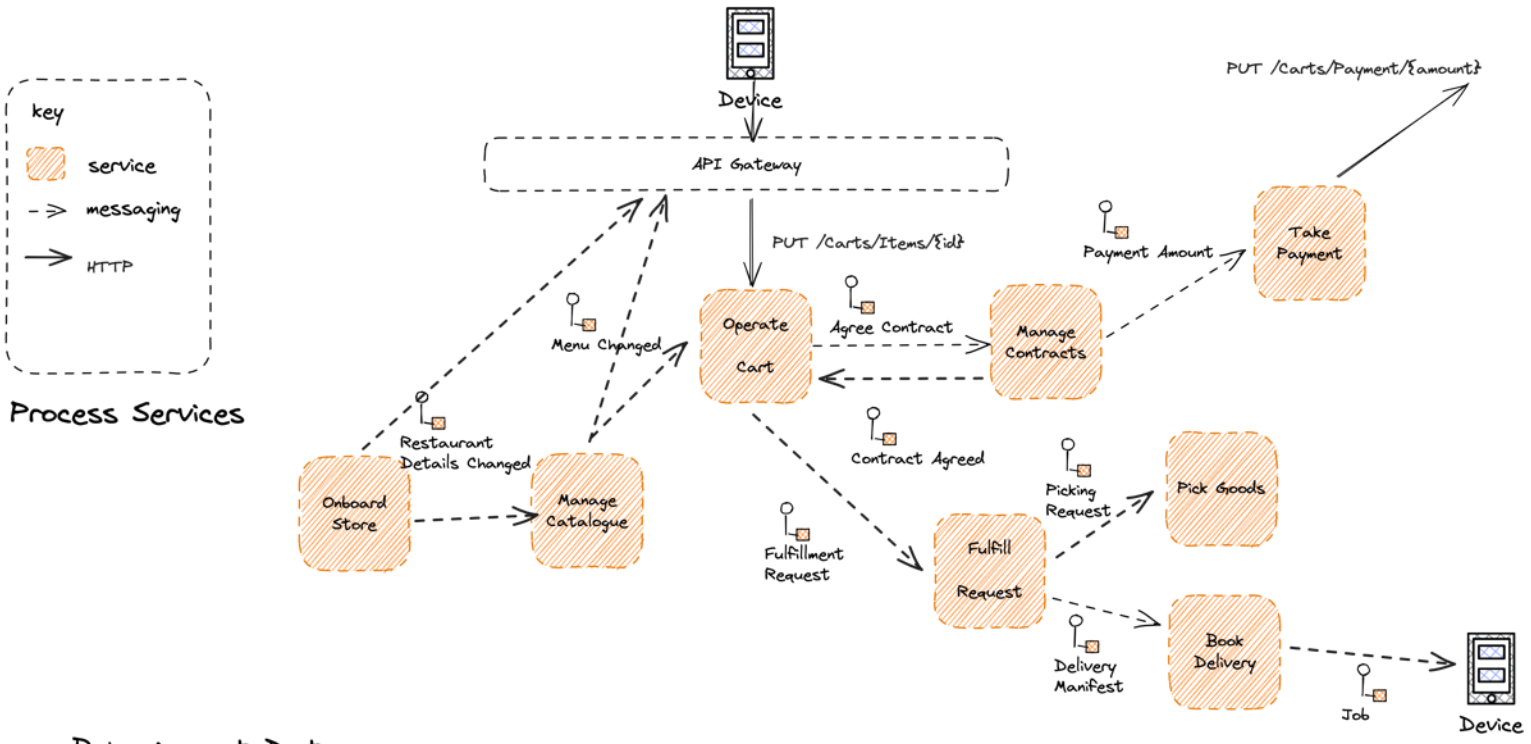
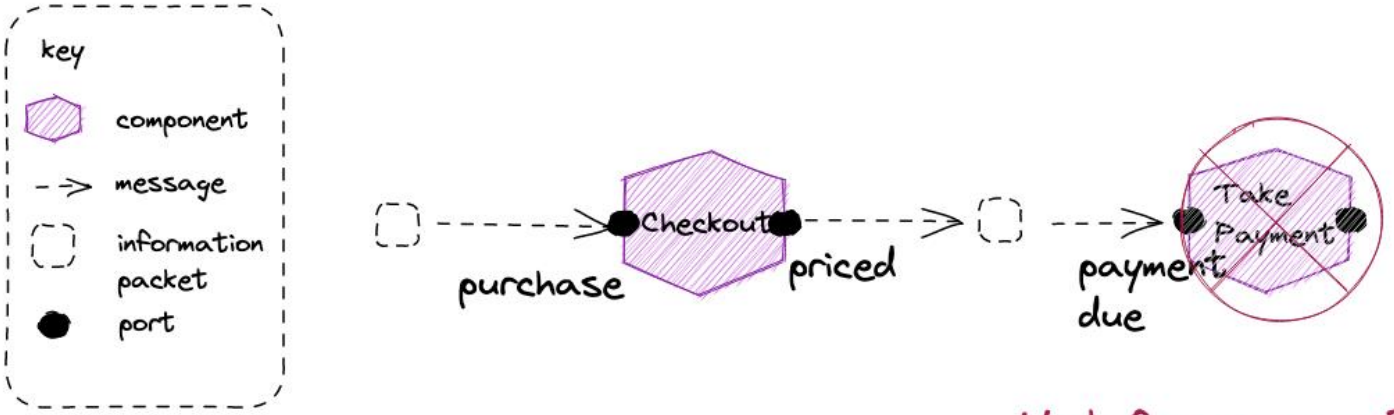
Purchase Refused
priced
payment due
Take Payment
request new card
payment refused
Pat Helland - Activity (State Machine)



Focus on Behavior not Data

I recommend thinking in terms of the service's responsibilities. (And don't say it's responsible for knowing some data!)
Does it apply policy? Does it aggregate a stream of concepts into a summary?
Does it facilitate some kinds of changes? Does it calculate something? And so on.
Notice how moving through the business process causes previous information to become effectively read-only?

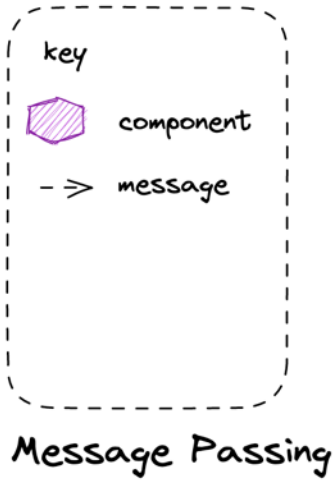
- Michael Nygard



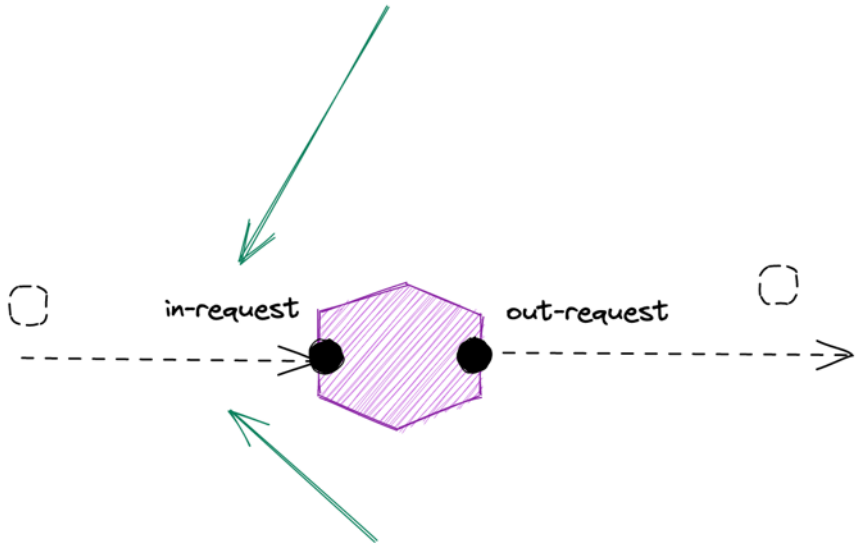
Work Queues on a Fault

If Take Payment is not available, we can queue requests. When it starts up, Take Payment can process those requests and respond as normal.

Bulkheads: In an asynchronous conversation a fault does not propagate back up the chain – we have a bulkhead that protects us against failure



Message Passing

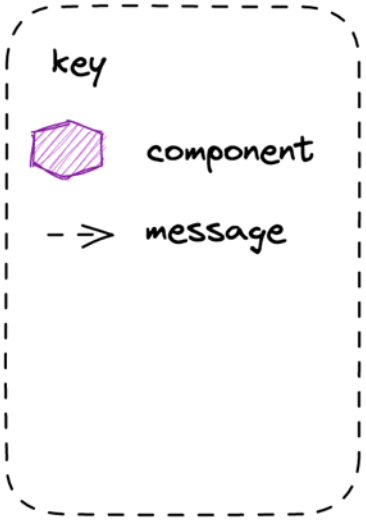


Push => open socket, middleware calls us as messages arrive
Pull => We poll for messages

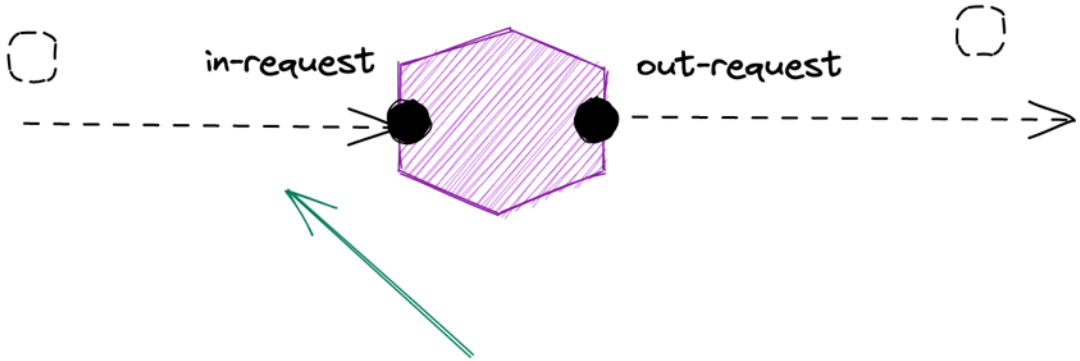
Backpressure

Push => Need to control how many messages are "in flight" with us
Pull => We control the rate at which we poll

Blocking Retry: Blocking Retry – when we keep trying to process a message, such as when we cannot connect to a DB and retry, creates backpressure as we slow consumption.

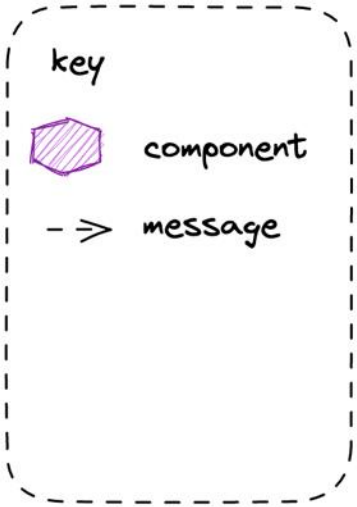


Message Passing

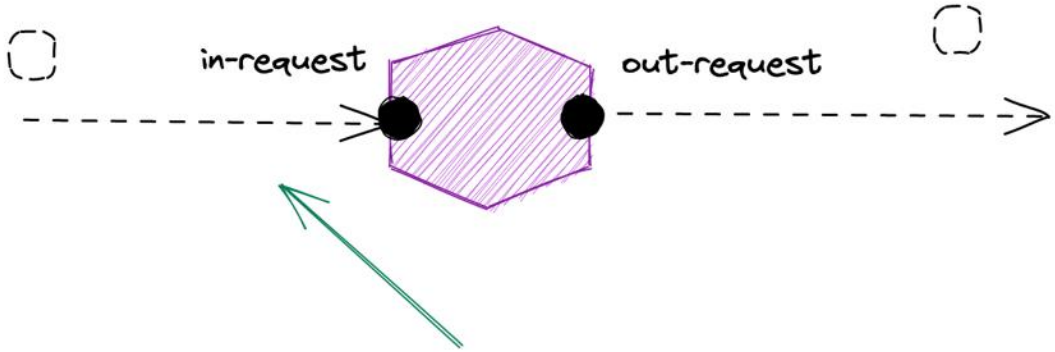


Load Shedding

Sometimes we may prefer to simply drop messages or shed load, when there is a fault.



Message Passing



Circuit Breaker

We may want to stop consuming, due to a fault. We can periodically let a message through to see if the fault has cleared.

Let it Crash Pattern

(Candea & Fox "Crash-Only Software)

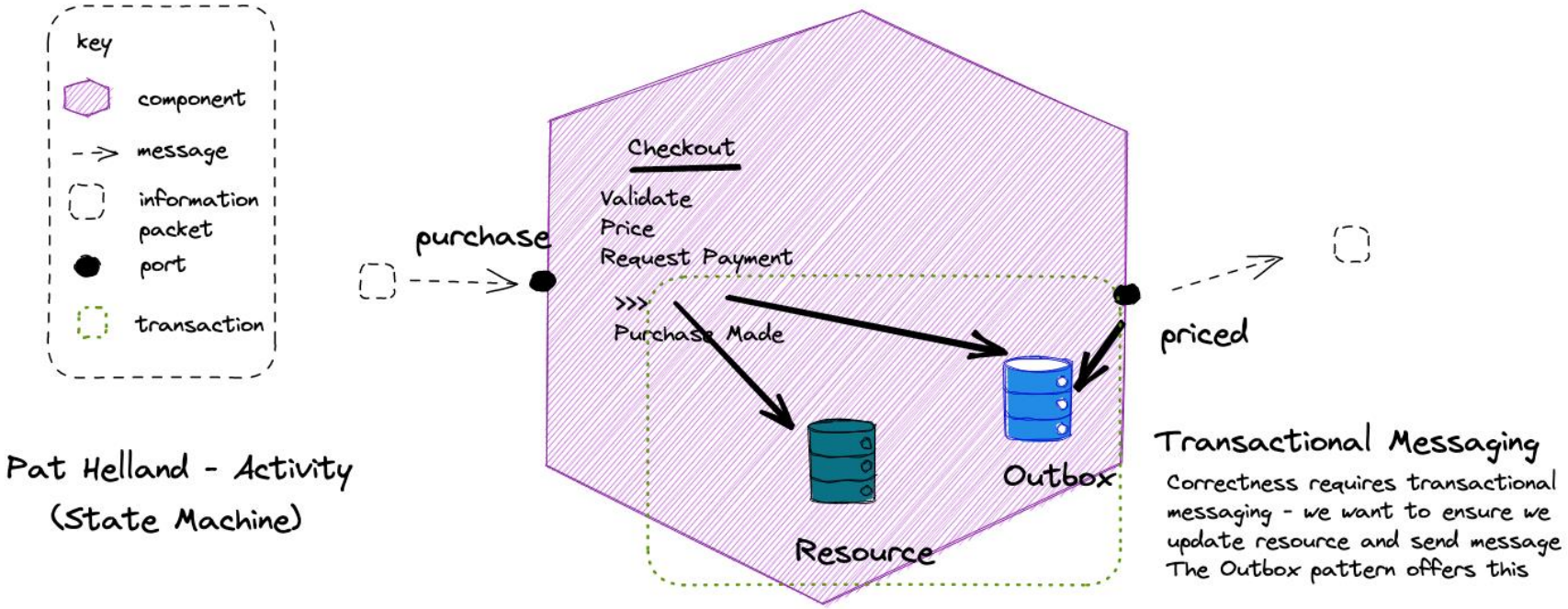
Transient or rare failures are hard to detect

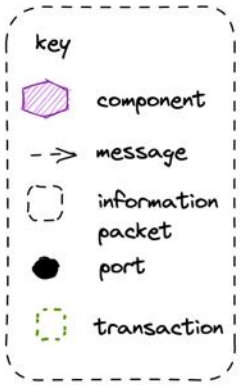
Recovery from a fault may be a complex problem

Crash and Restart =>

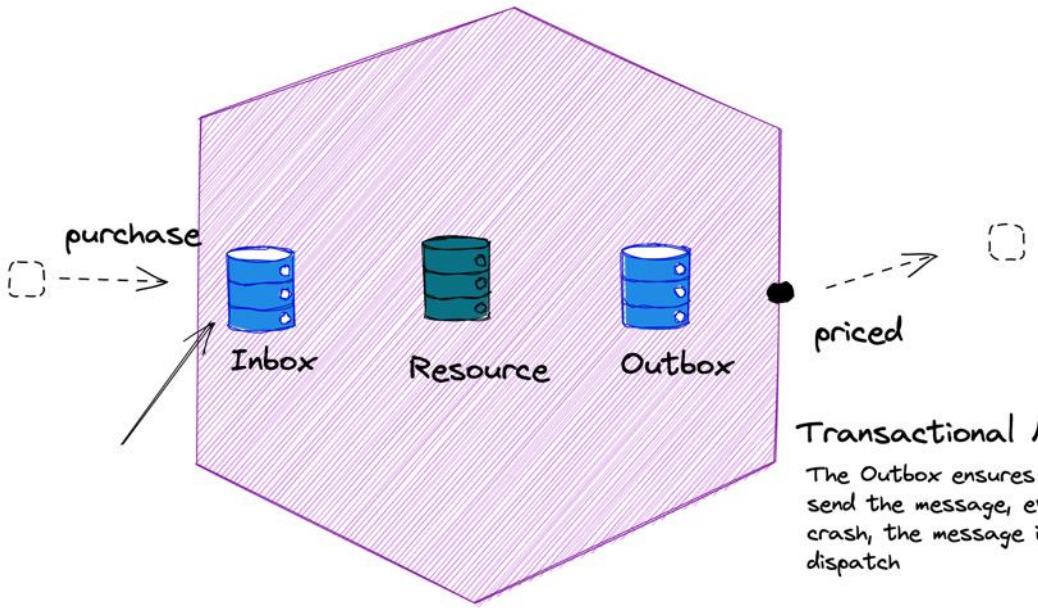
Start Up is Recovery

Shut Down is Clean


key
component
message
information packet
port
transaction
Checkout
Validate
Price
Request Payment
>>>
Purchase Made
purchase
priced
Outbox
Resource
Transactional Messaging
Correctness requires transactional messaging - we want to ensure we update resource and send message
The Outbox pattern offers this
Pat Helland - Activity (State Machine)

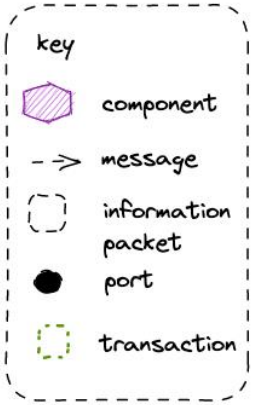


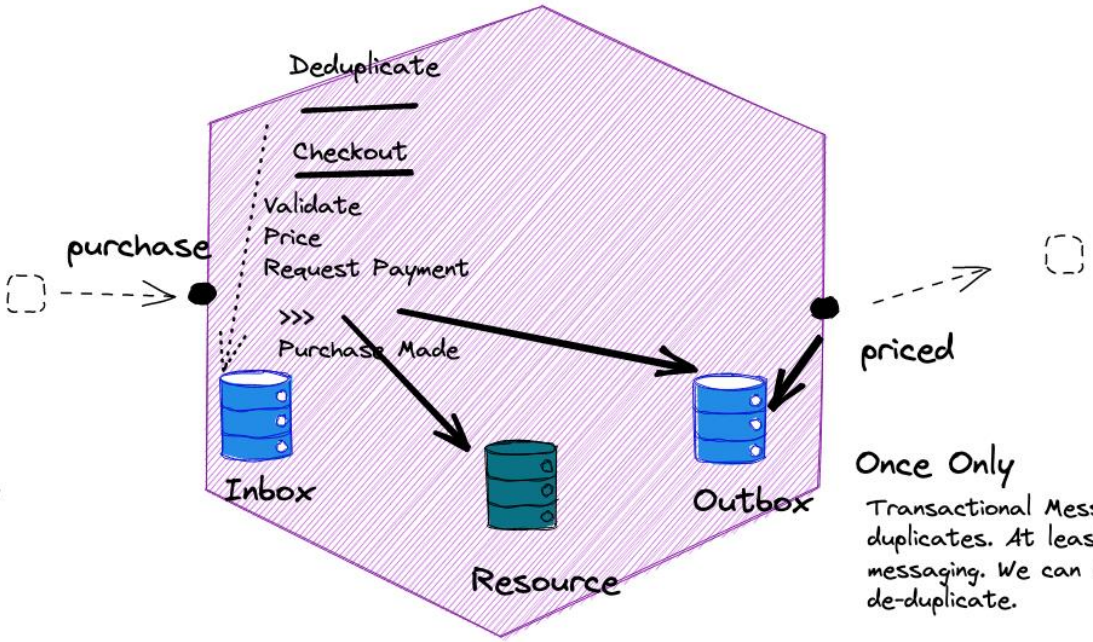
Let It Crash



Transactional Messaging

The Outbox ensures that we will eventually send the message, even if our component should crash, the message is in the Outbox for later dispatch

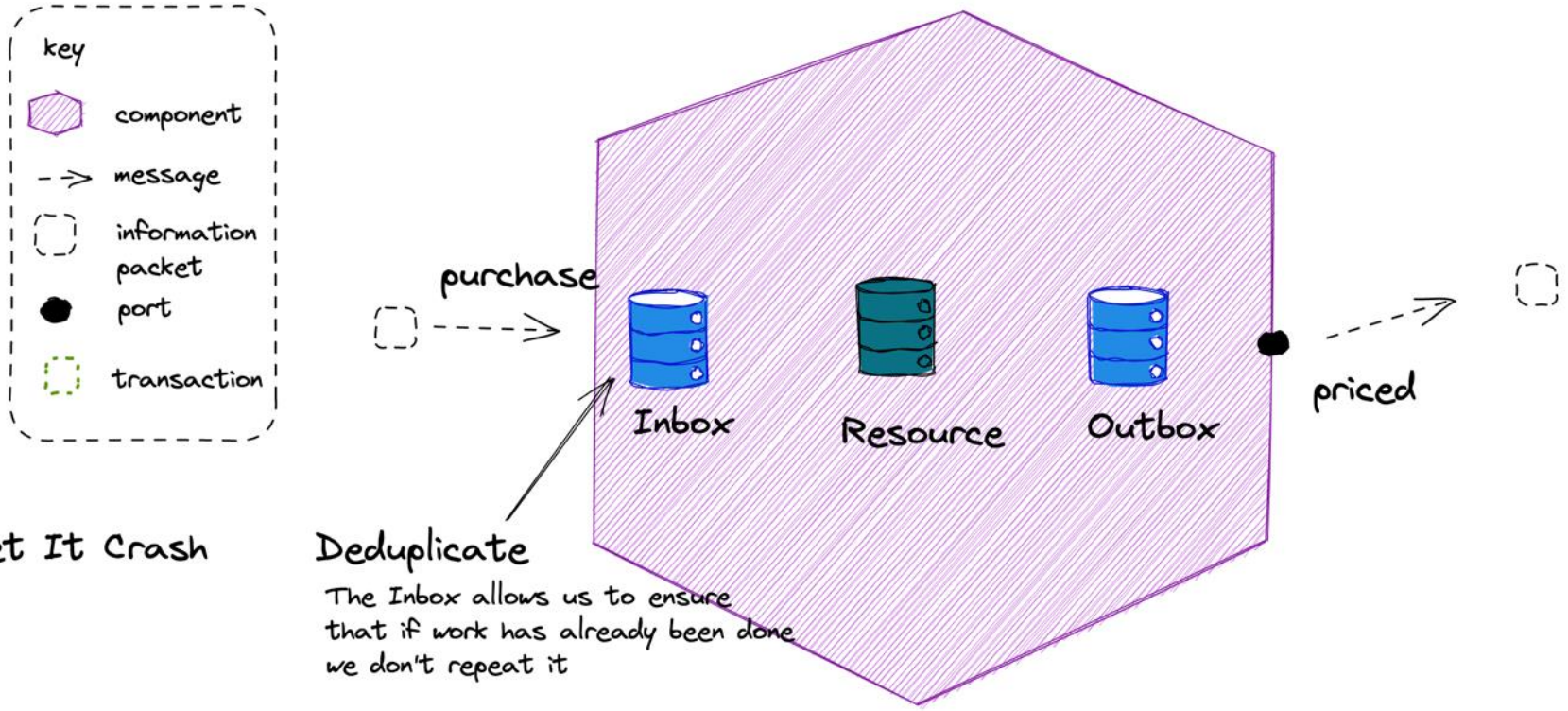


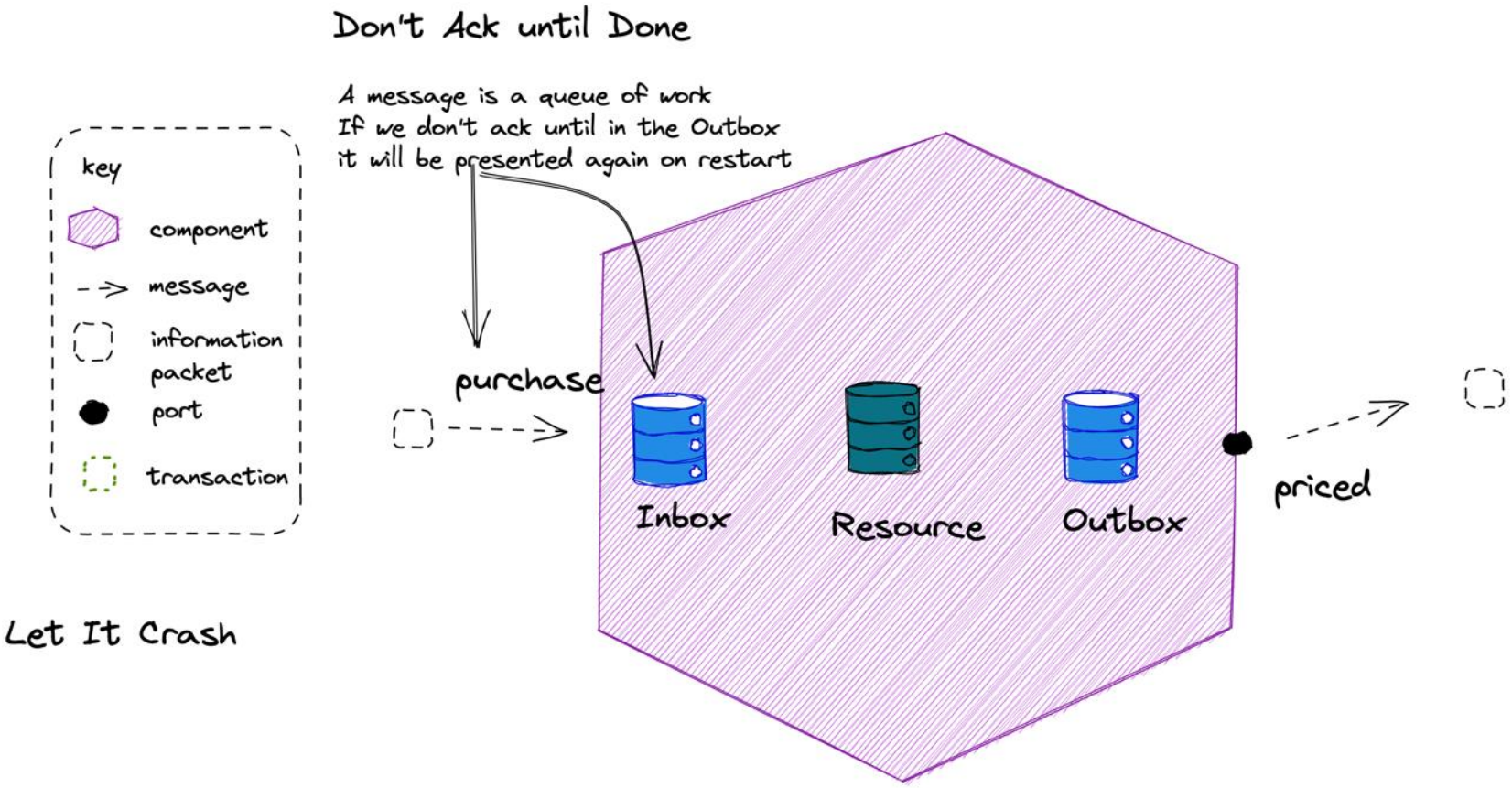


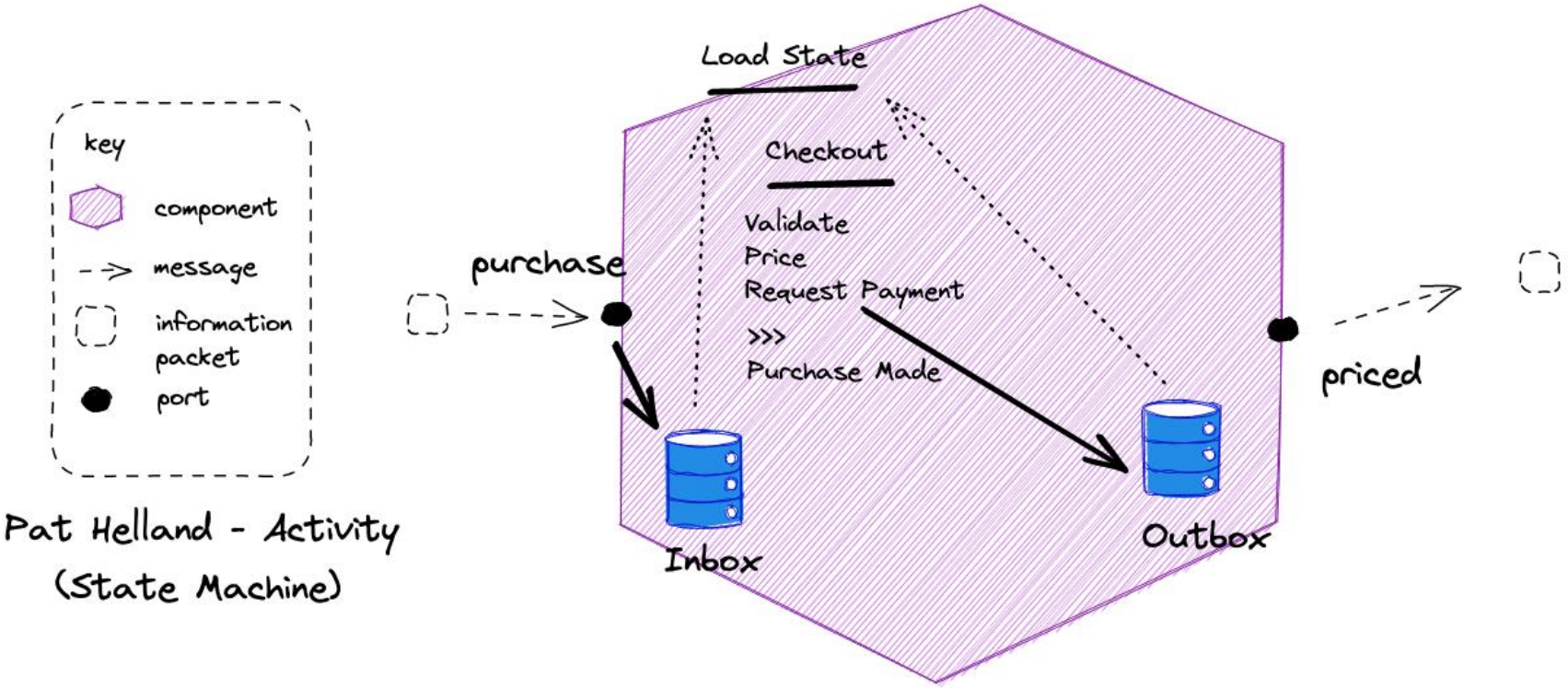
Pat Helland - Activity (State Machine)

Once Only

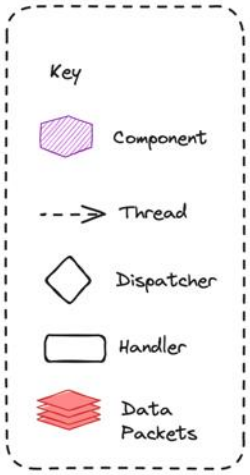
Transactional Messaging will send us duplicates. At least once, guaranteed messaging. We can use an Inbox to de-duplicate.

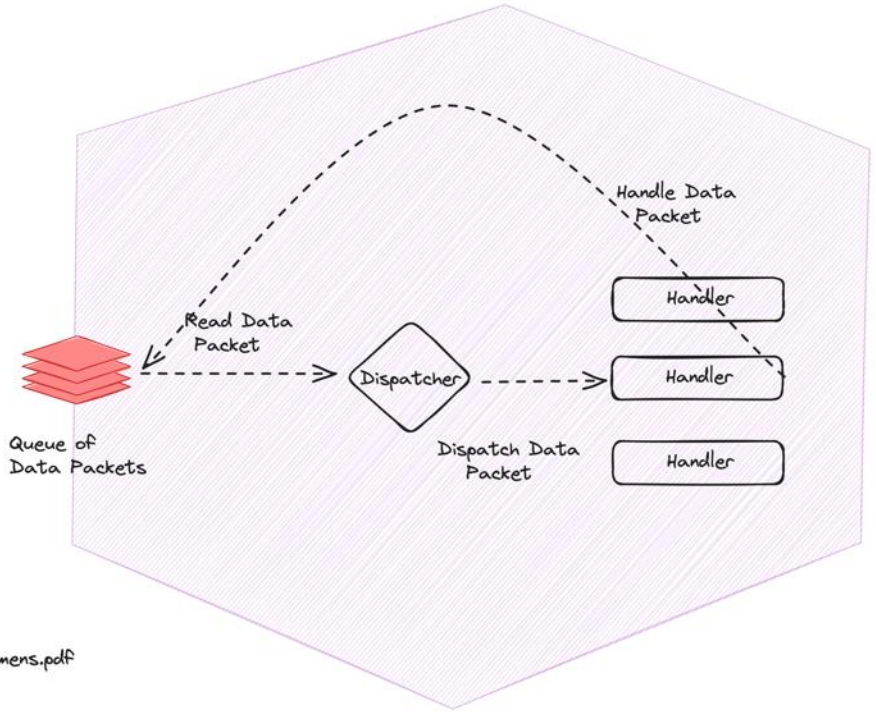

key
component
message
information packet
port
transaction
purchase
Inbox
Resource
Outbox
priced
Let It Crash
Deduplicate
The Inbox allows us to ensure that if work has already been done we don't repeat it


Don't Ack until Done
A message is a queue of work
If we don't ack until in the Outbox
it will be presented again on restart
key
component
message
information packet
port
transaction
purchase
Inbox
Resource
Outbox
priced
Let It Crash



It is possible to calculate activity state by comparing the inbox and outbox to determine where a flow reached, in the event of failure, over storing current state.





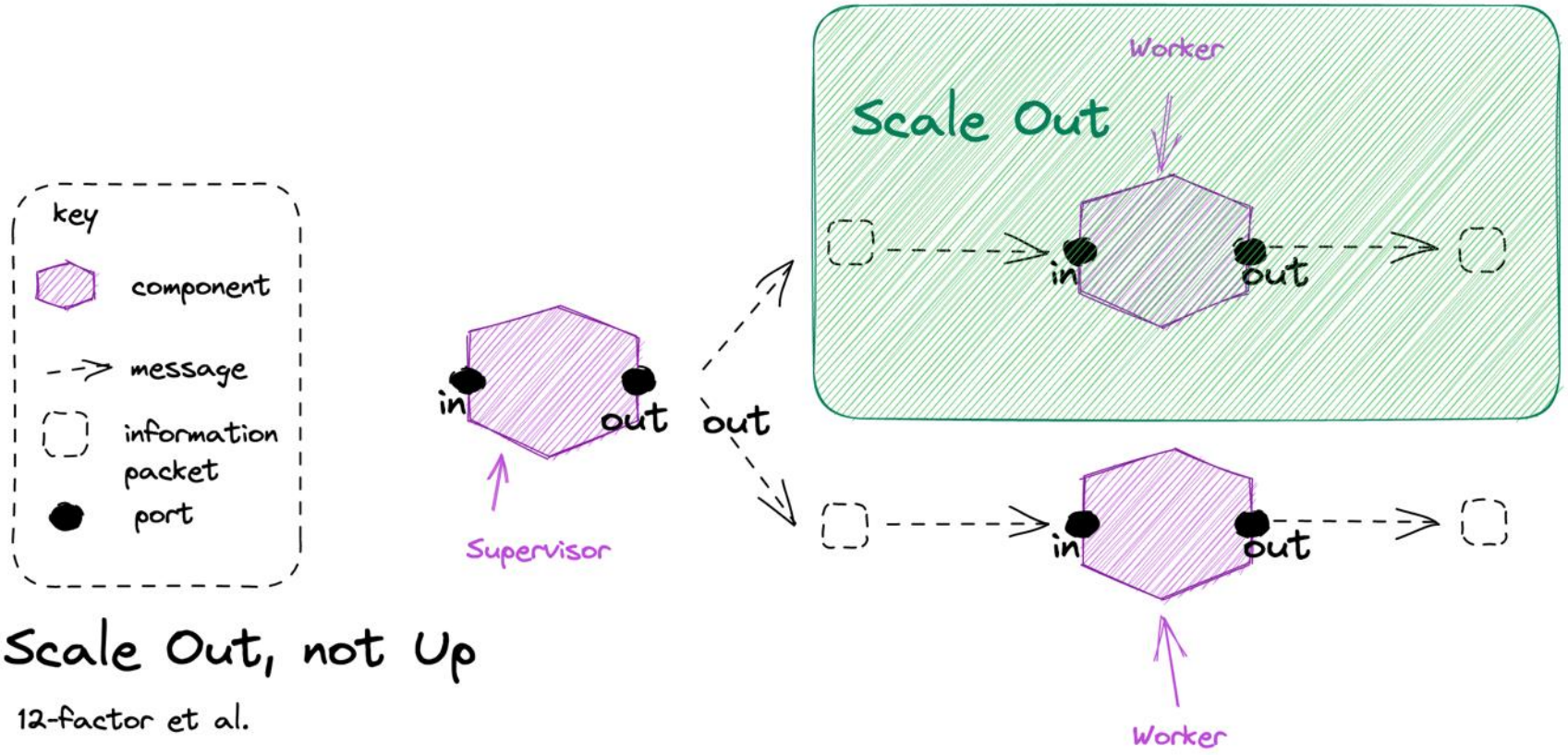
Reactor Pattern

Douglas Schmidt
http://www.dre.vanderbilt.edu/~schmidt/PDF/reactor-siemens.pdf

Single Threaded

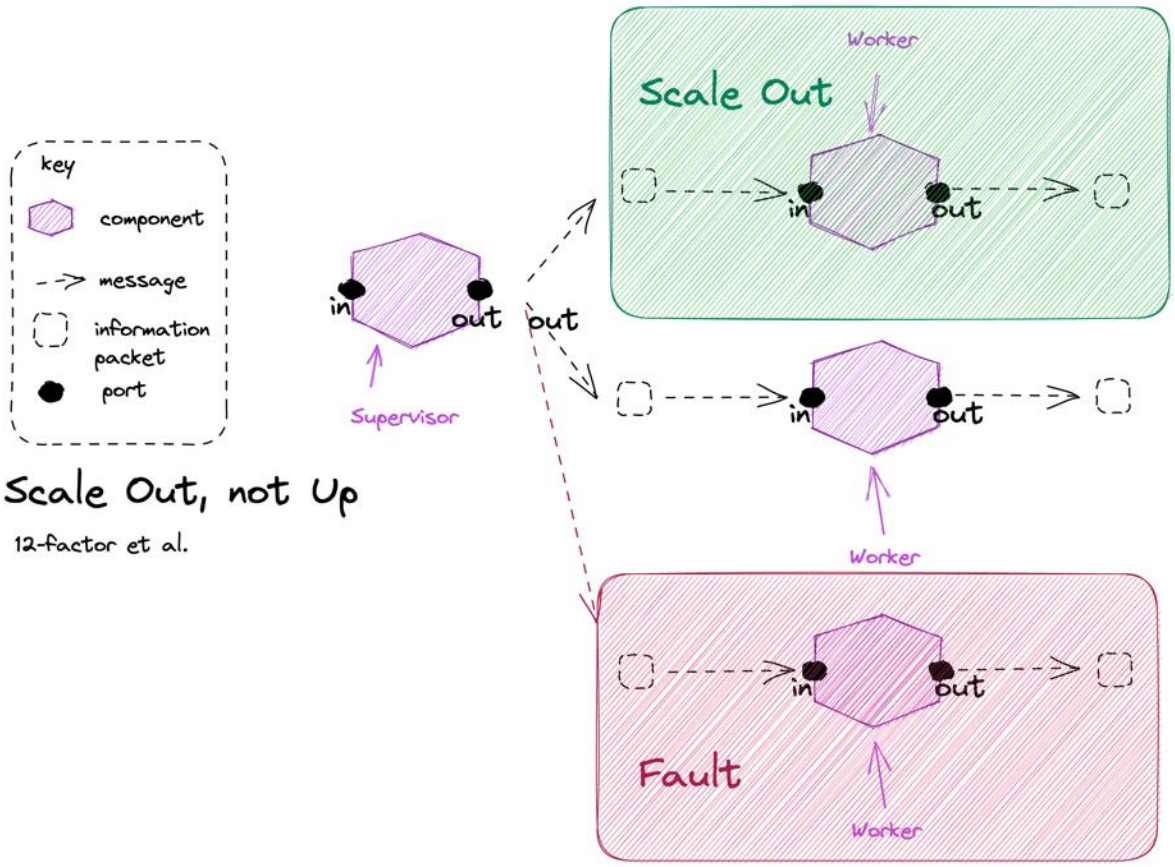
The Reactor uses a single thread to: read from the queue; dispatch to a handler; and execute the handler.

Note that this preserves ordering and does not require locking to protect mutable state.



Scale Out, not Up

12-factor et al.



Scale Out, not Up

12-factor et al.

Paper Workflows

"My life looked good on paper - where, in fact, almost all of it was being lived." - Martin Amis

Messaging/Discrete Event

Discrete, Immediately Actioned

Skinny

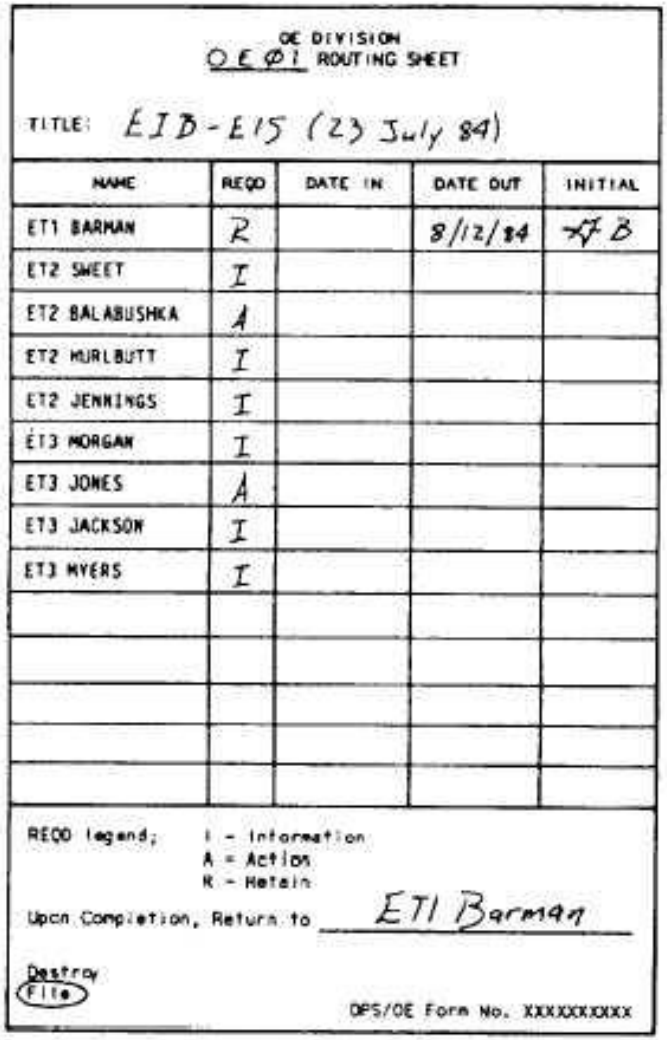
Series Event (Document)

Series, Supports Action

Fat


OUT
IN
gettyimages
Comstock Images
78431769


J. Rastberg



OE DIVISION
OEØ1 ROUTING SHEET

TITLE: EIB-EI5 (23 July 84)

NAME	REQD	DATE IN	DATE OUT	INITIAL
ET1 BARMAN	R		8/12/84	AFB
ET2 SWEET	I			
ET2 BALABUSHKA	A			
ET2 MURLBUTT	I			
ET2 JENNINGS	I			
ET3 MORGAN	I			
ET3 JONES	A			
ET3 JACKSON	I			
ET3 MYERS	I			

REQD legend; I - Information
A - Action
R - Retain

Upon Completion, Return to ET1 Barman

Destroy
File

OPS/OE Form No. XXXXXXXXX


FAX
brother

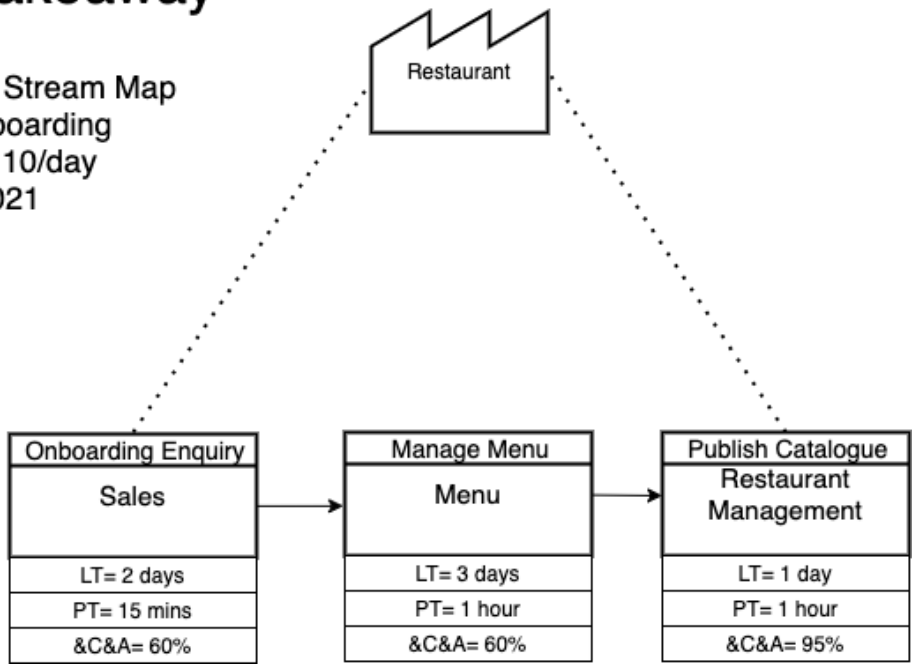
What is a microservice?

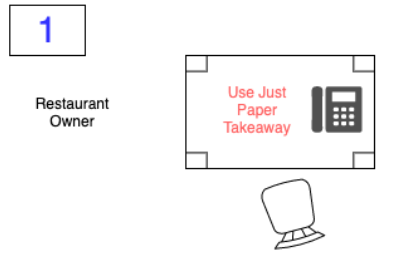
SOA is focused on business *processes*. These *processes* are performed in different steps (also called *activities* or *tasks*) on different systems. The primary goal of a **service** is to represent a "natural" step of business functionality. That is, according to the domain for which it's provided, *a service should represent a self-contained functionality that corresponds to a real-world business activity*.

Josuttis, Nicolai M.. SOA in Practice: The Art of Distributed System Design . O'Reilly Media. Kindle Edition.

Just Paper Takeaway

Current State Value Stream Map
Restaurant Onboarding
Demand Rate 10/day
29 SEP 2021

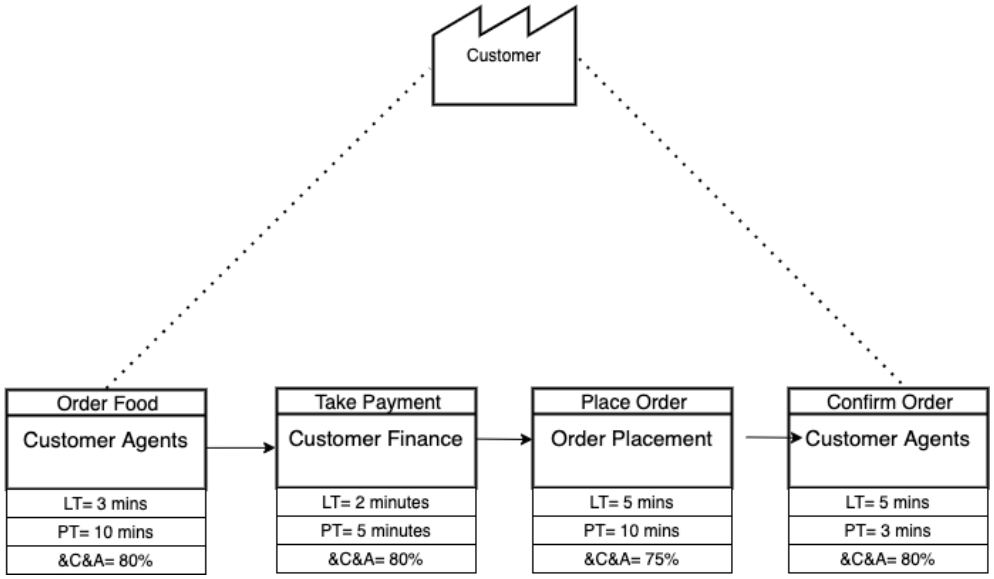


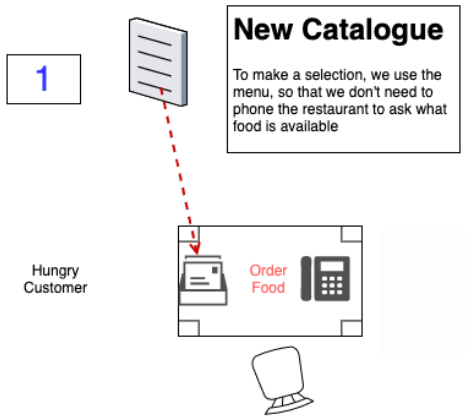


Restaurant Onboarding

Just Paper Takeaway

Current State Value Stream Map
Order Flow
Demand Rate 10/day
29 SEP 2021

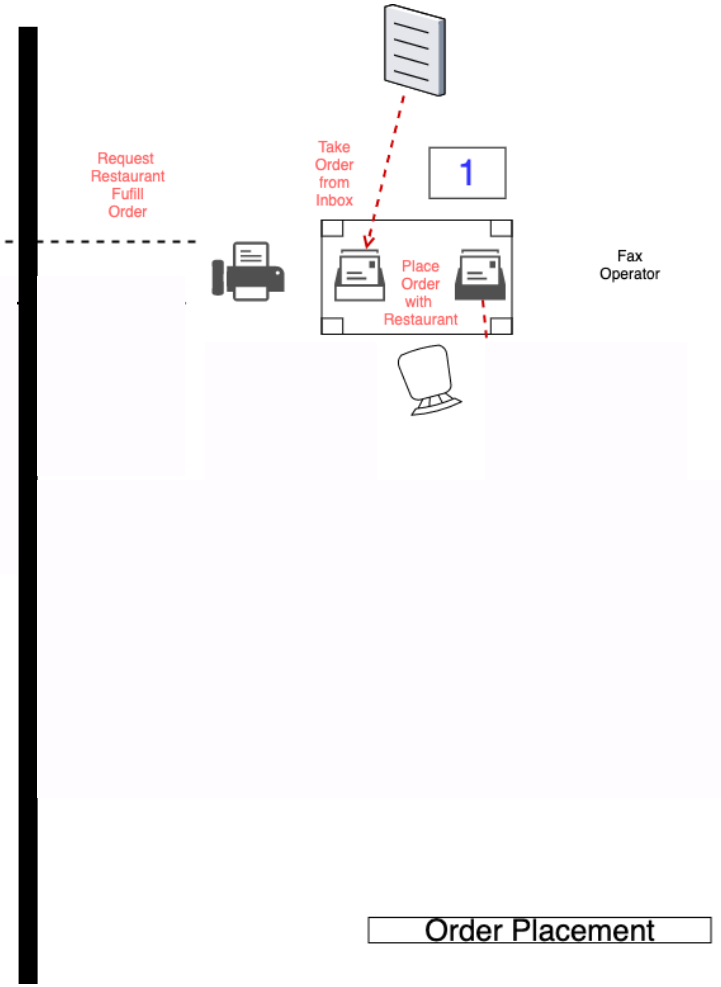


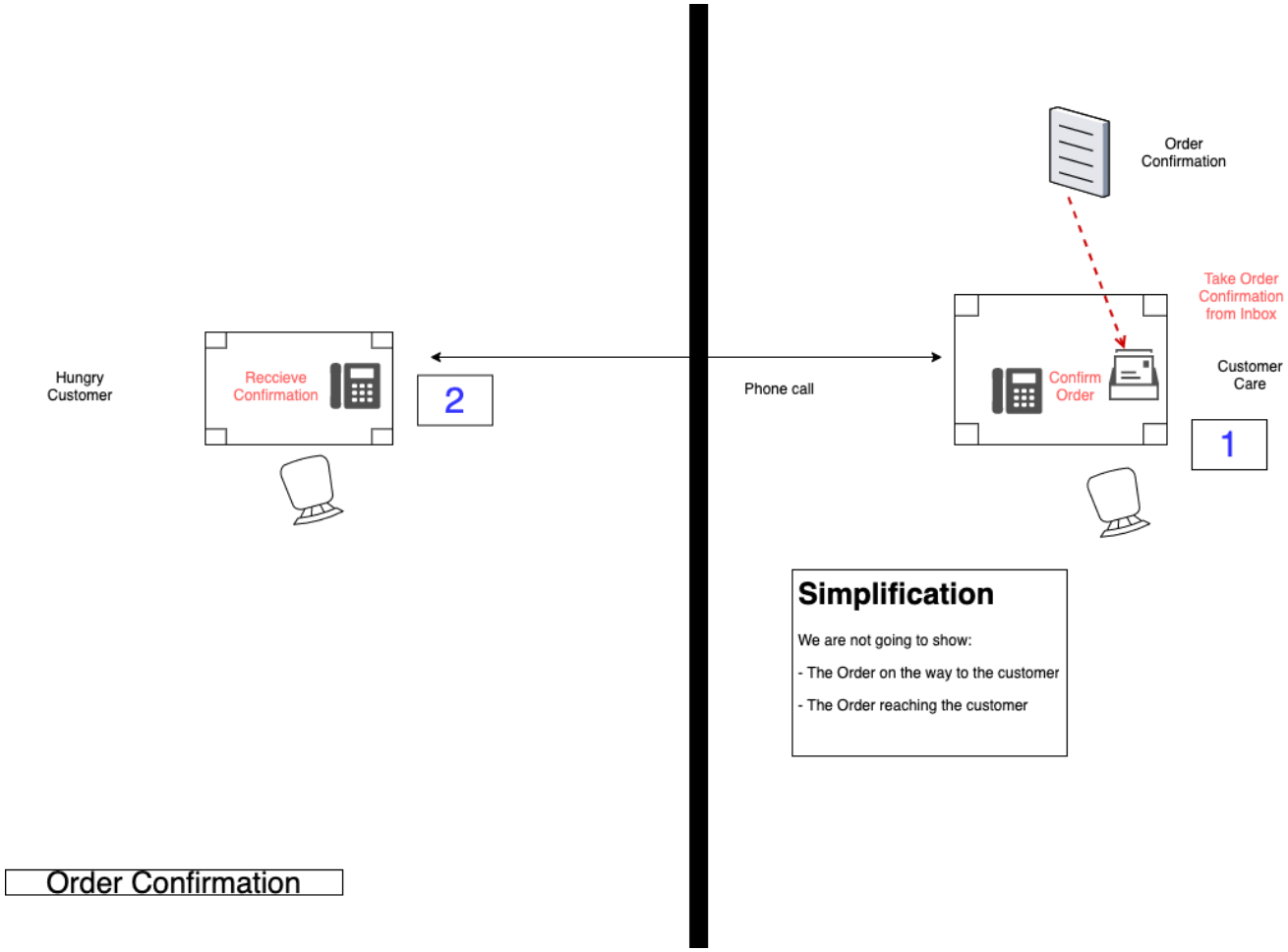


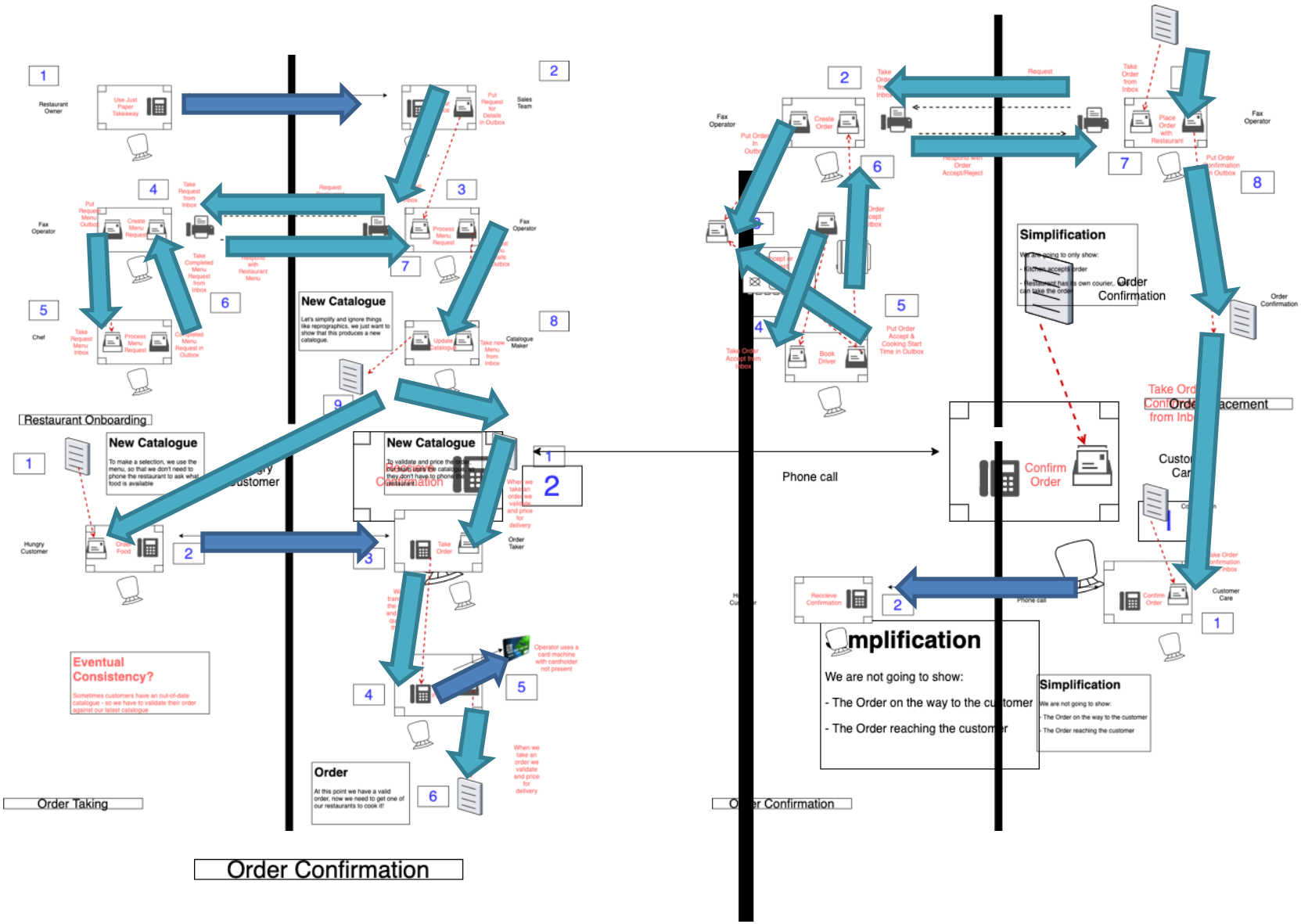
Order Taking

Order Wheel


Jon 104 2
484812
1 Cæ GF
2 Wedge Bbs
1 Gr. Salmon MR
2 NY Strip M
No Pl. on Spinach
Thank You!

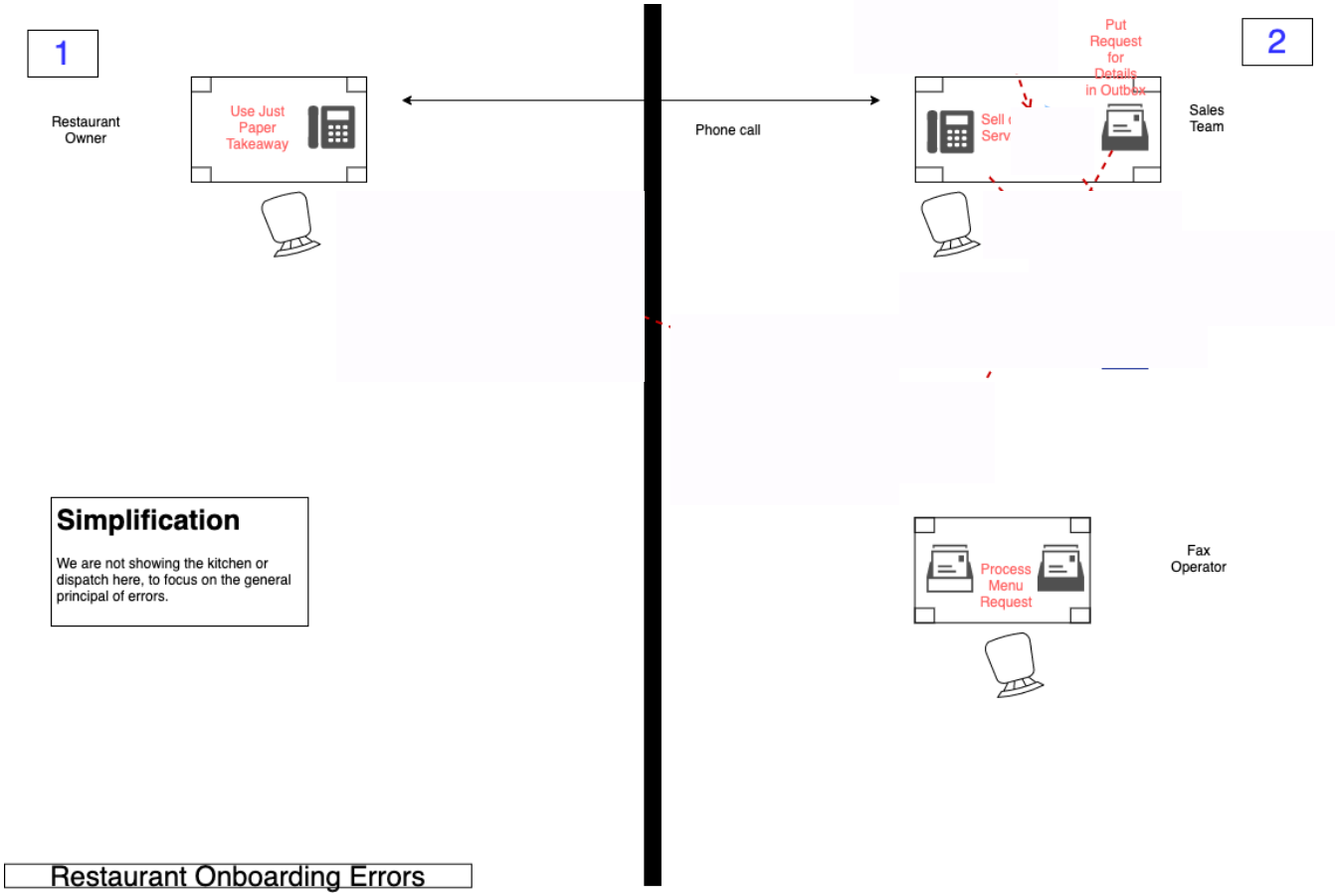

Request
Restaurant
Fufill
Order
Take
Order
from
Inbox
1
Place
Order
with
Restaurant
Fax
Operator
Order Placement


Order Confirmation
Take Order Confirmation from Inbox
Hungry Customer
Reccieve Confirmation
2
Phone call
Confirm Order
Customer Care
1
Simplification
We are not going to show:
- The Order on the way to the customer
- The Order reaching the customer
Order Confirmation


Restaurant Onboarding
New Catalogue
Let's simplify and ignore things like reprographics, we just want to show that this produces a new catalogue.
New Catalogue
To make a selection, we use the menu, so that we don't need to phone the restaurant to ask what food is available
New Catalogue
Eventual Consistency?
Sometimes customers have an out-of-date catalogue - so we have to validate their order against our latest catalogue
Order
At this point we have a valid order, now we need to get one of our restaurants to cook it!
Order Taking
Order Confirmation
Phone call
Confirm Order
Simplification
We are not going to show:
- The Order on the way to the customer
- The Order reaching the customer
Order Confirmation

Compensation

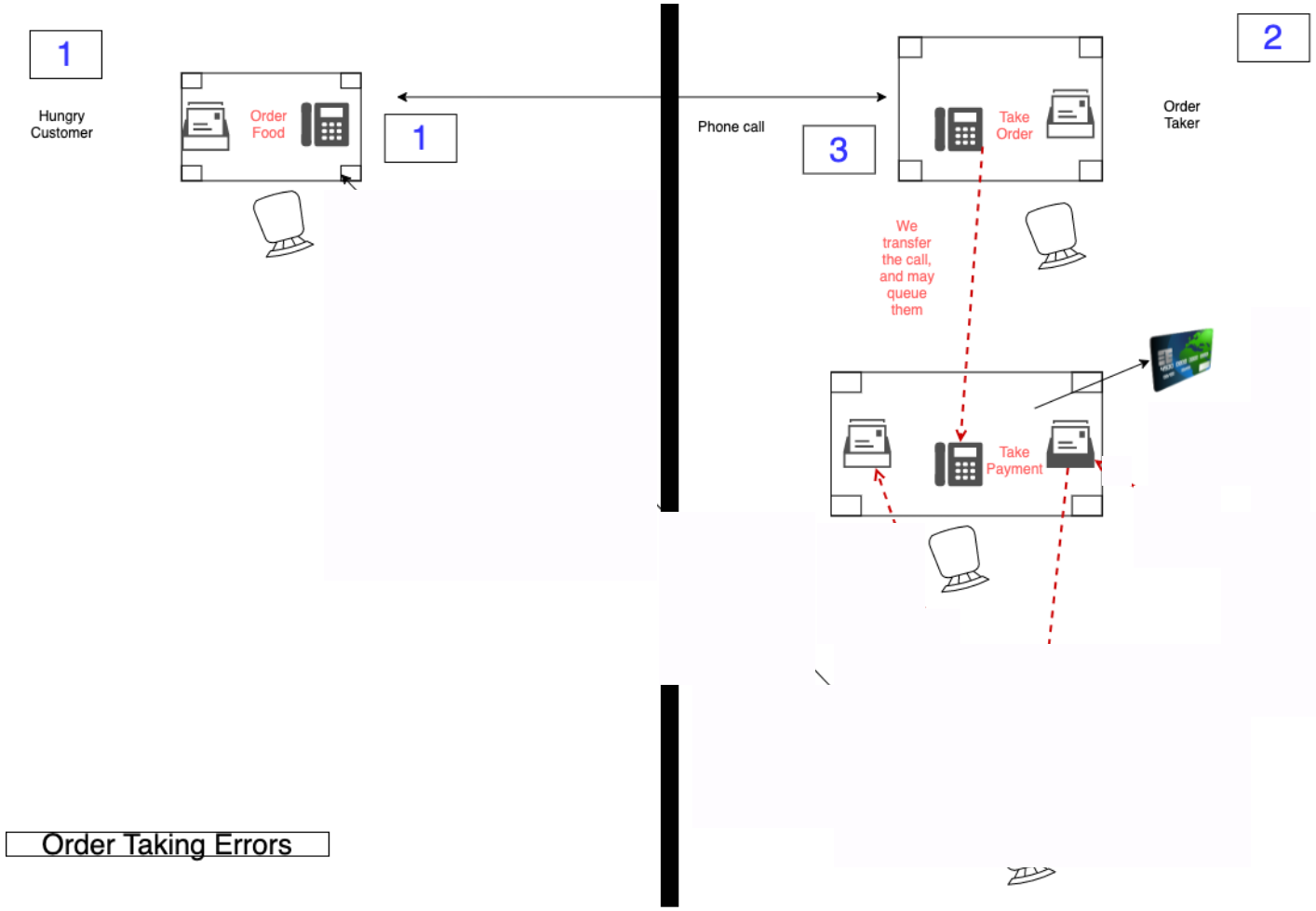

DO NOT USE!
Scrap Cost


1
Restaurant Owner
Use Just Paper Takeaway
Phone call
Put Request for Details in Outbox
2
Sales Team
Simplification
We are not showing the kitchen or dispatch here, to focus on the general principal of errors.
Process Menu Request
Fax Operator
Restaurant Onboarding Errors

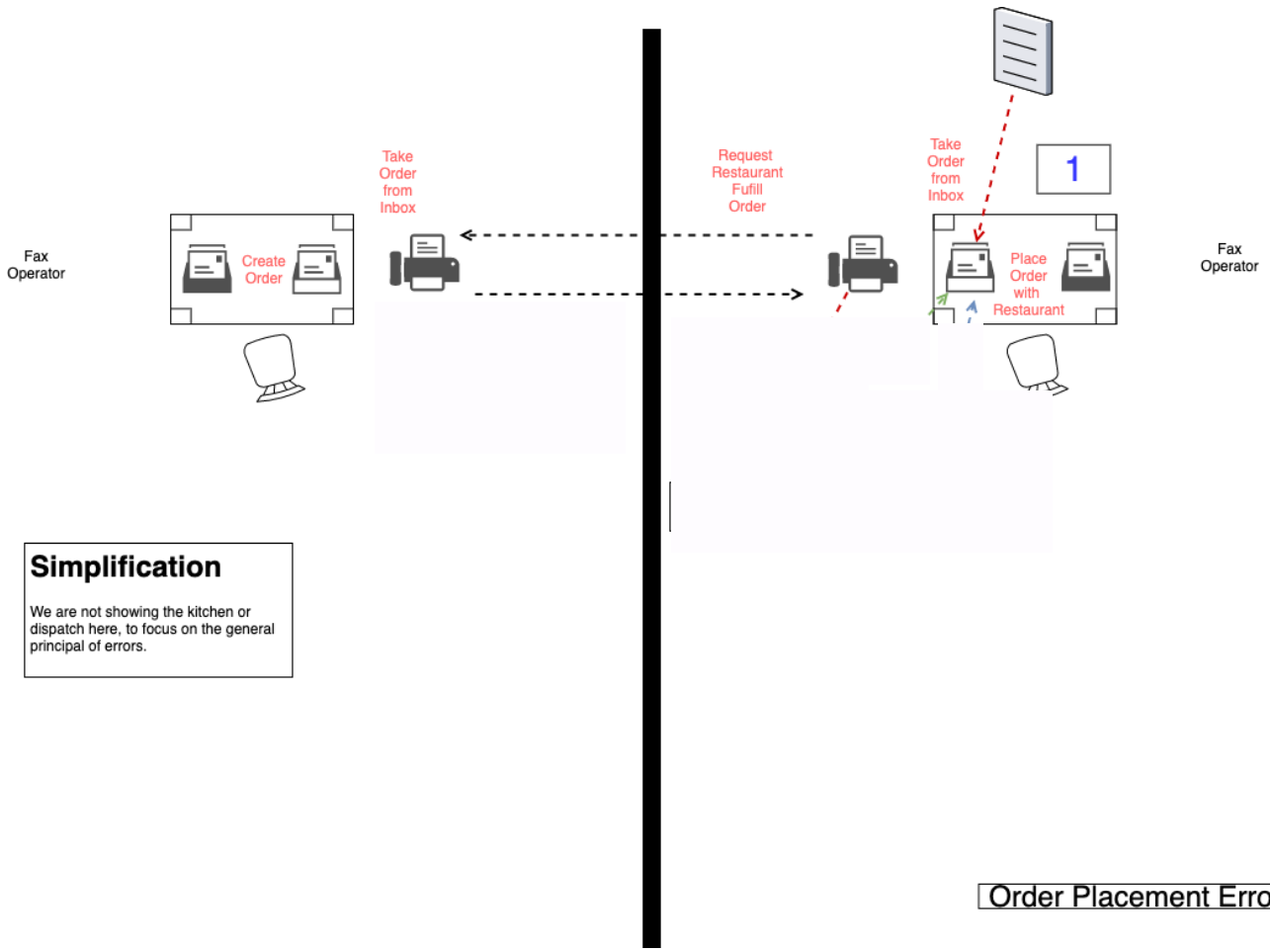
Fax Call Log

Monday, 2010-11-08 11:19

Date	Time	Type	Job #	Length	Speed	Station Name/Number	Pages	Status
2010-06-18	08:31	SCAN	92	0:25	28800	[illegible]	0	E-705 V.34 1M31
2010-03-22	11:39	RECV	59	0:20	26400	[illegible]	1	OK -- V.34 BM31
2010-03-22	11:45	RECV	60	0:20	26400	[illegible]	1	OK -- V.34 BM31
2010-03-22	12:29	RECV	61	0:21	26400	[illegible]	1	OK -- V.34 BM31
2010-09-14	14:46	SCAN	129	1:40	9600	[illegible]	2	E-606 V.29 AR30



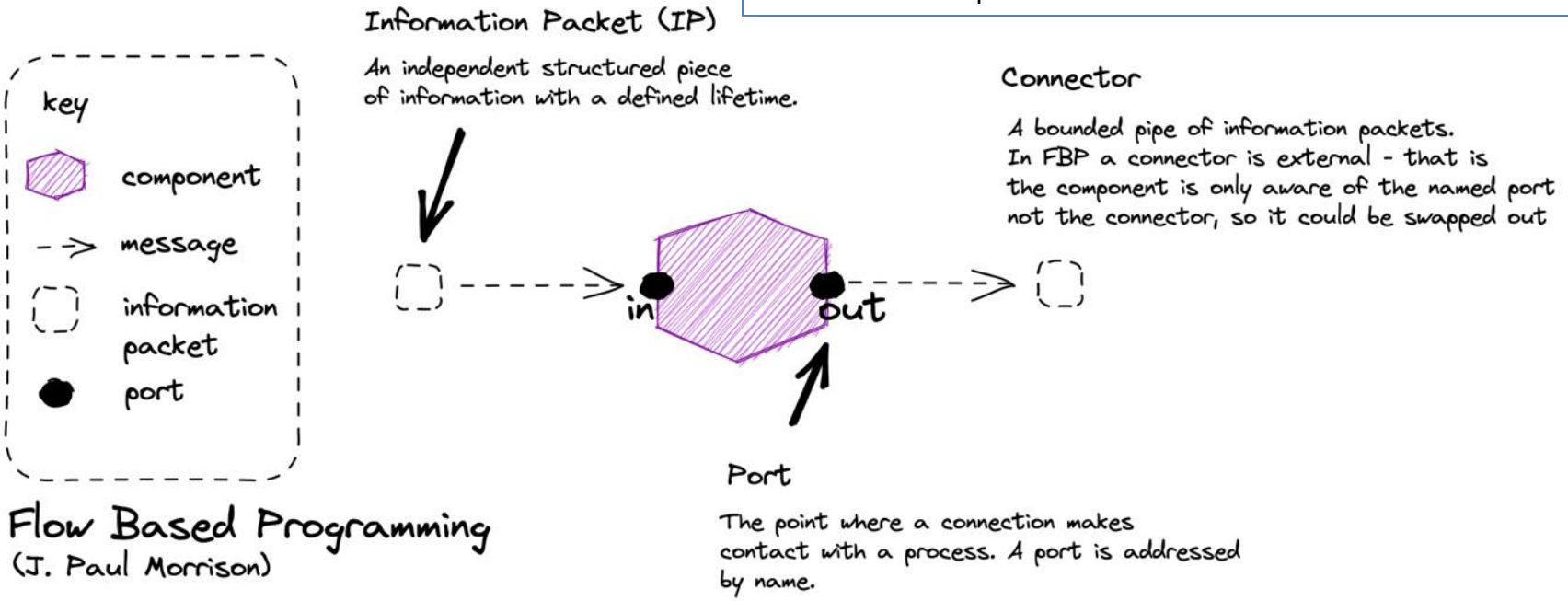
Order Taking Errors

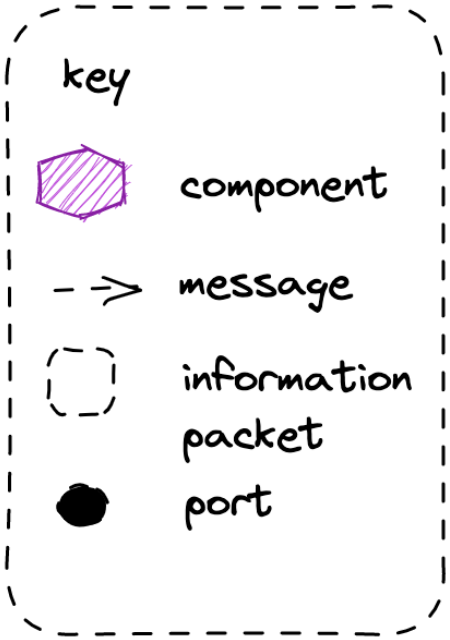

Fax
Operator
Create
Order
Take
Order
from
Inbox
Request
Restaurant
Fufill
Order
Take
Order
from
Inbox
1
Place
Order
with
Restaurant
Fax
Operator
Simplification
We are not showing the kitchen or dispatch here, to focus on the general principal of errors.
Order Placement Errors

Flow Based Programming

"Everything Flows and Nothing Stays." - Heraclitus

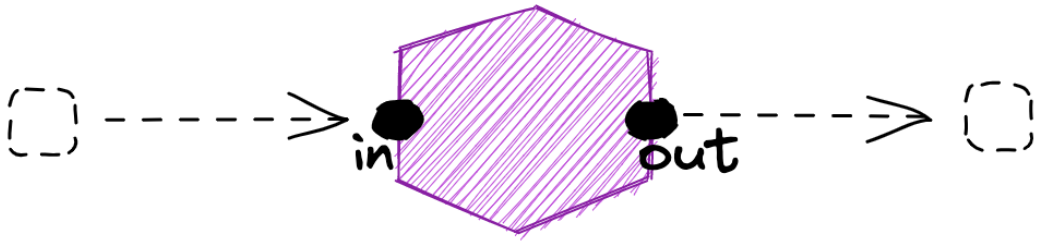
Flow-Based Programming (FBP) is a subclass of DFP. While DFP can be synchronous or asynchronous, FBP is always asynchronous. FBP allows multiple input ports, has bounded buffers and applies back pressure when buffers fill up.





Packet Lifetime

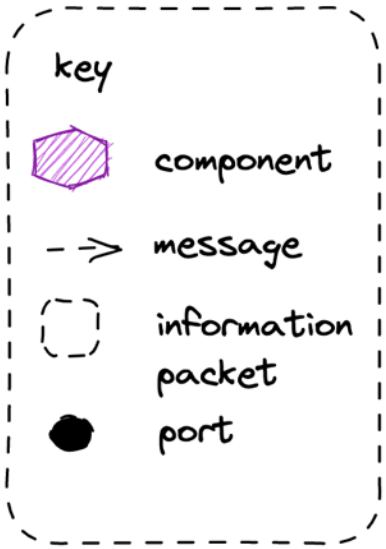
Packet Lifetime



Process & Wait

Flow Based Programming
(J. Paul Morrison)

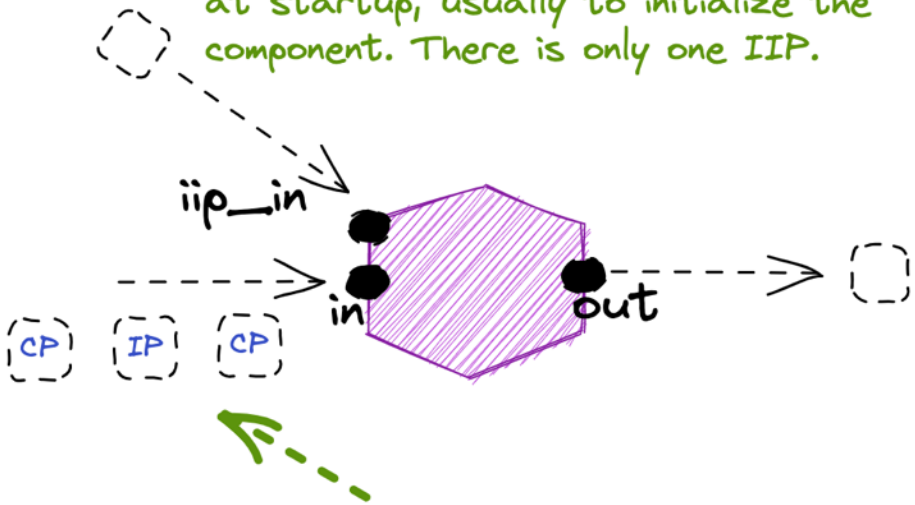
Node Lifetime: In flow base programming the a node can remain running whilst there is work on an input queue, can can suspend instead of terminate if there is no work on its connector.



Flow Based Programming
(J. Paul Morrison)

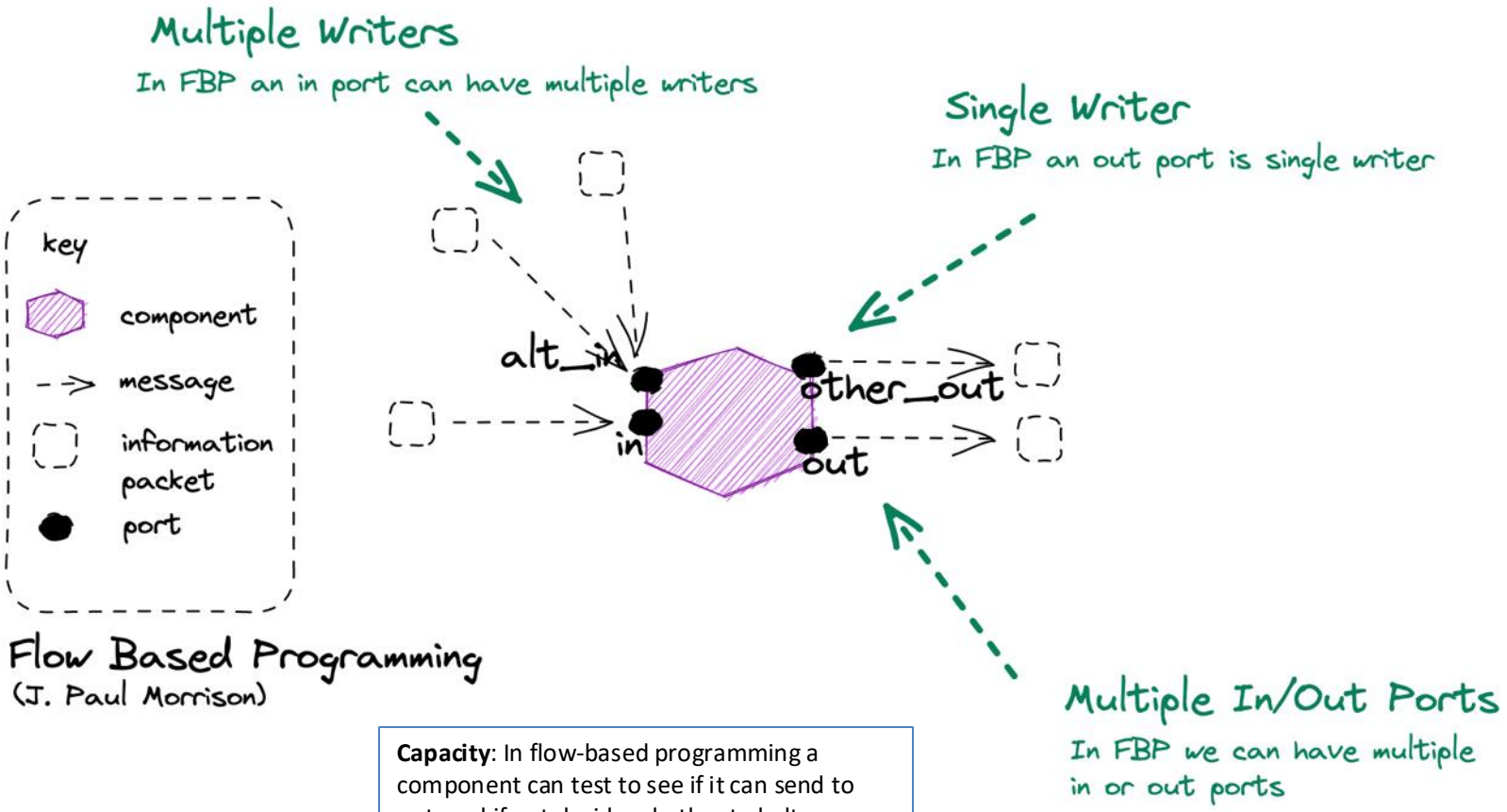
Initial Information Packet

A packet that the component reads at startup, usually to initialize the component. There is only one IIP.

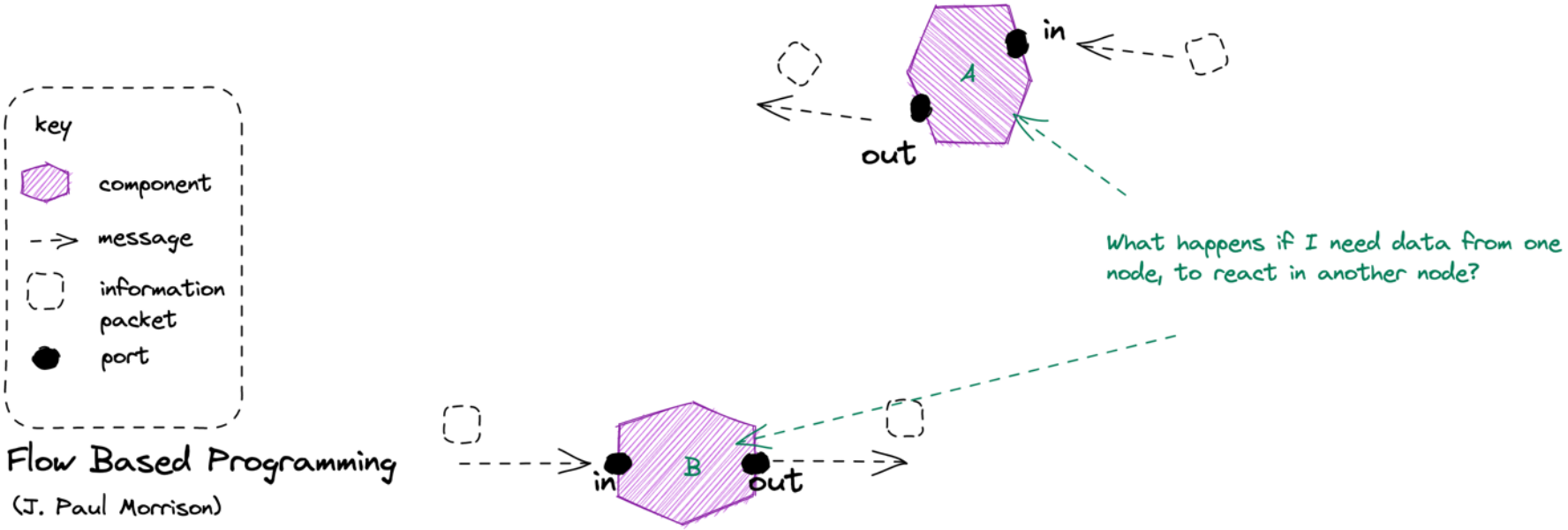


Control Packets

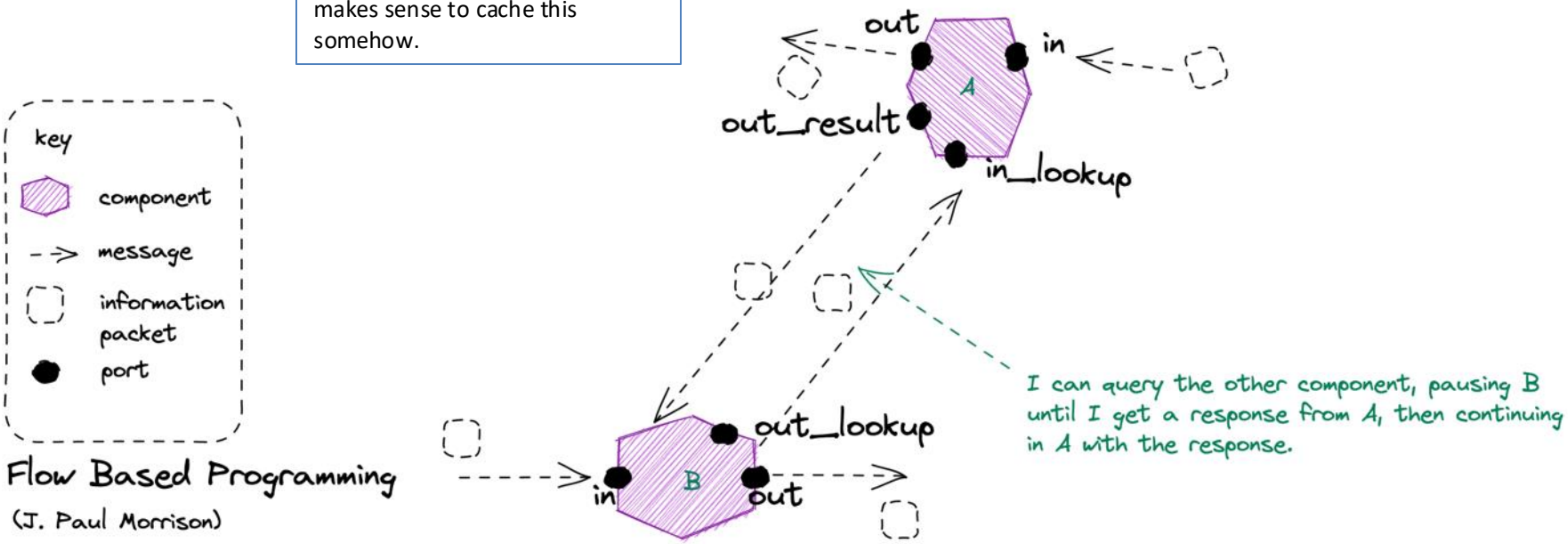
Control Packets can be used to 'bracket' groups

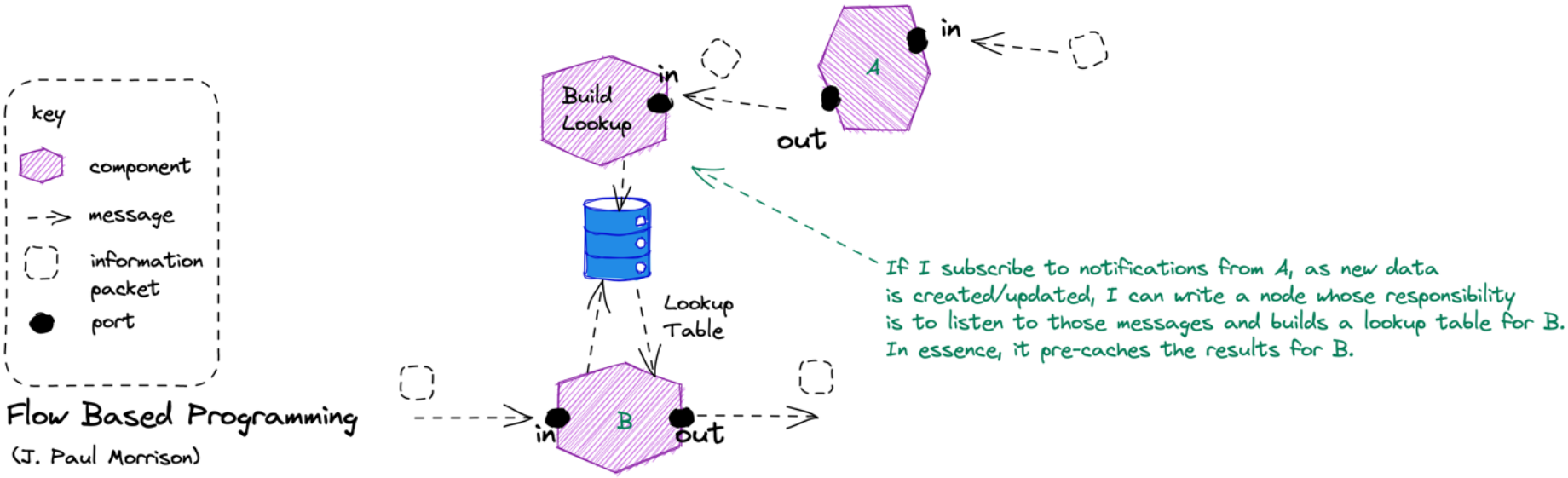


Capacity: In flow-based programming a component can test to see if it can send to out, and if not decide whether to halt or ignore.


key
component
message
information packet
port
Flow Based Programming
(J. Paul Morrison)
A
in
out
What happens if I need data from one node, to react in another node?
B
in
out

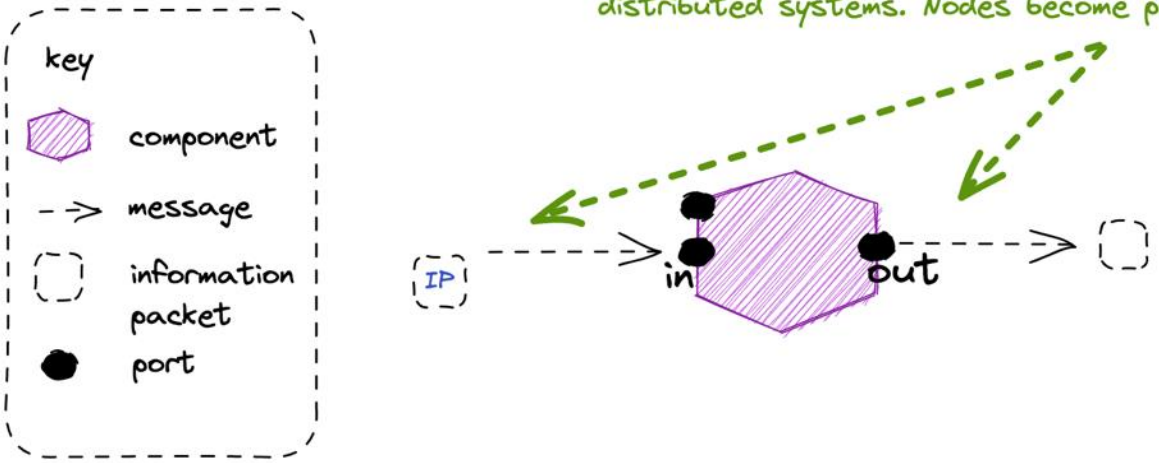
Walk of Shame: The trouble is that we may keep asking, so it makes sense to cache this somehow.



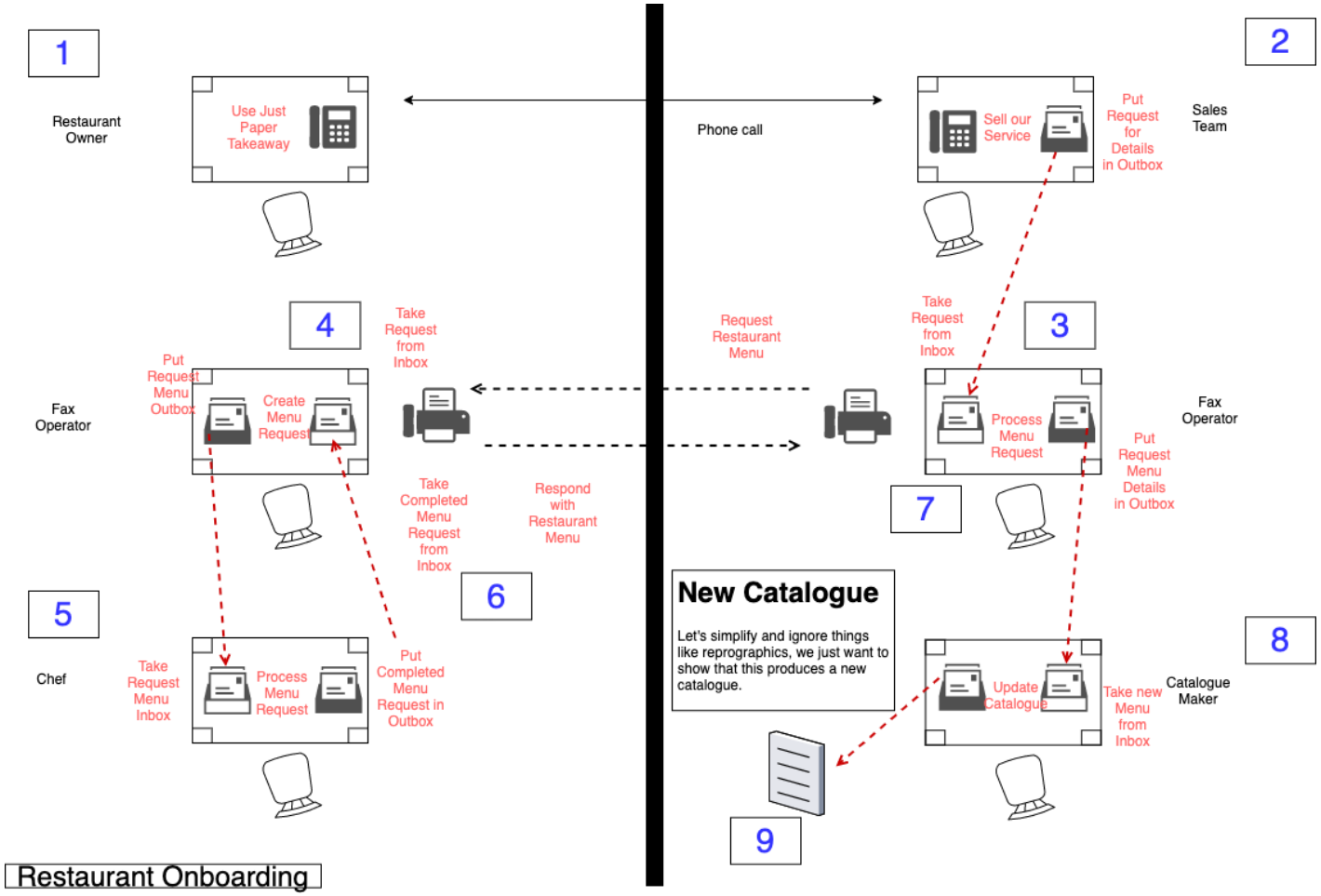

key
component
message
information packet
port
Flow Based Programming
(J. Paul Morrison)
Build Lookup
in
out
A
in
Lookup Table
in
B
out
If I subscribe to notifications from A, as new data is created/updated, I can write a node whose responsibility is to listen to those messages and builds a lookup table for B. In essence, it pre-caches the results for B.

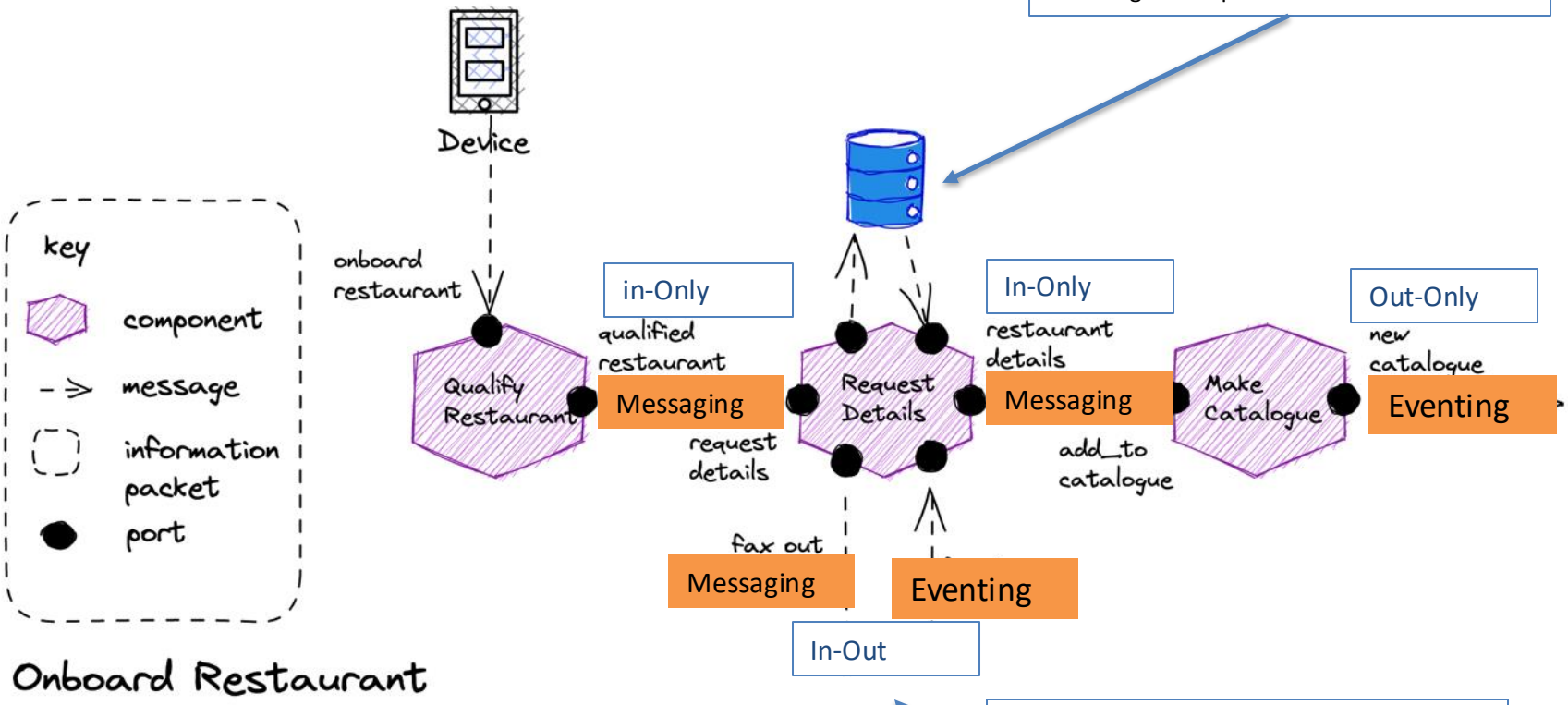
Message Oriented Middleware (MoM)

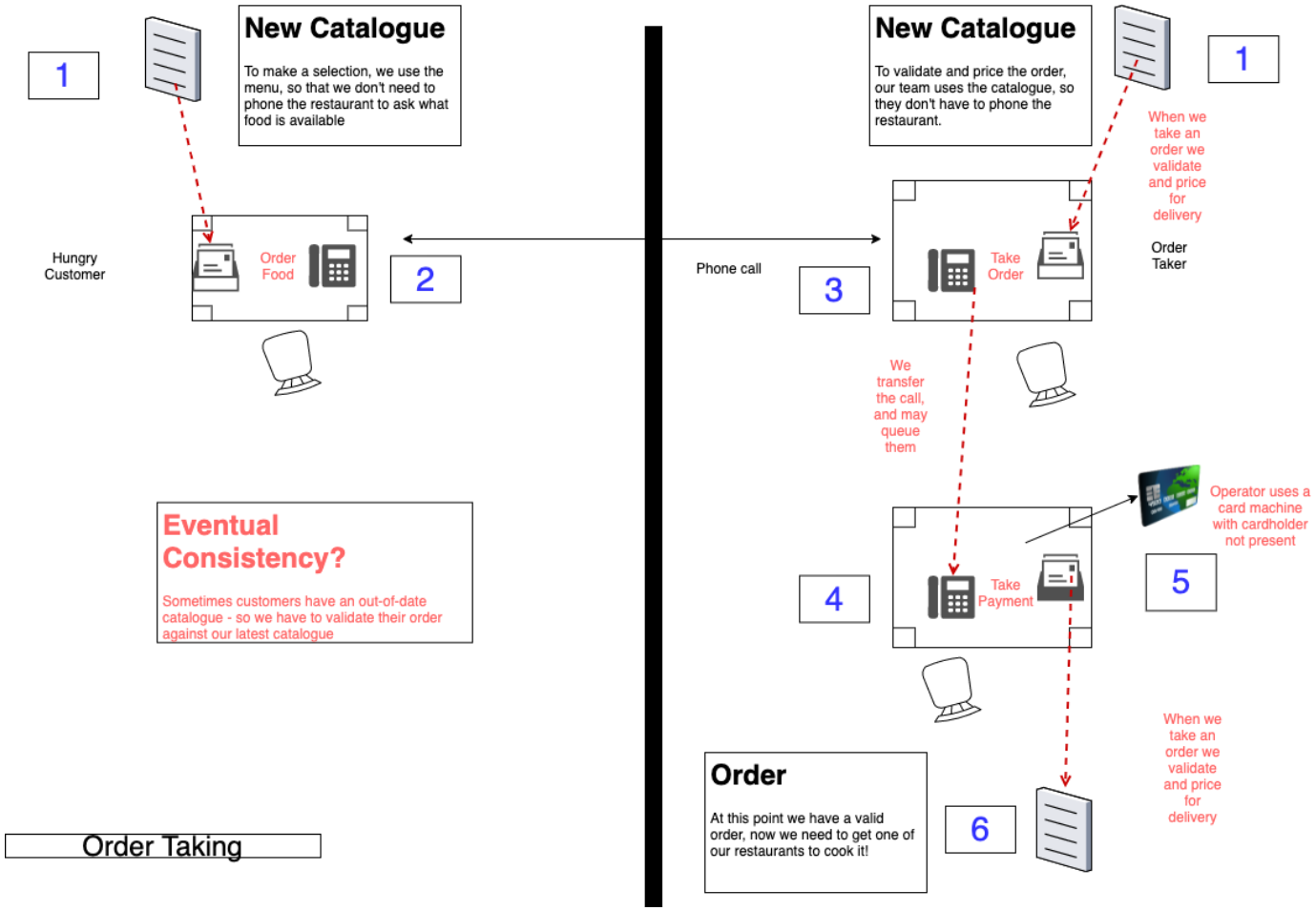
Because FBP allows for externally defined connectors in the 2010 update JPM outlined that it could be used in distributed systems. Nodes become processes and connectors use MoM.

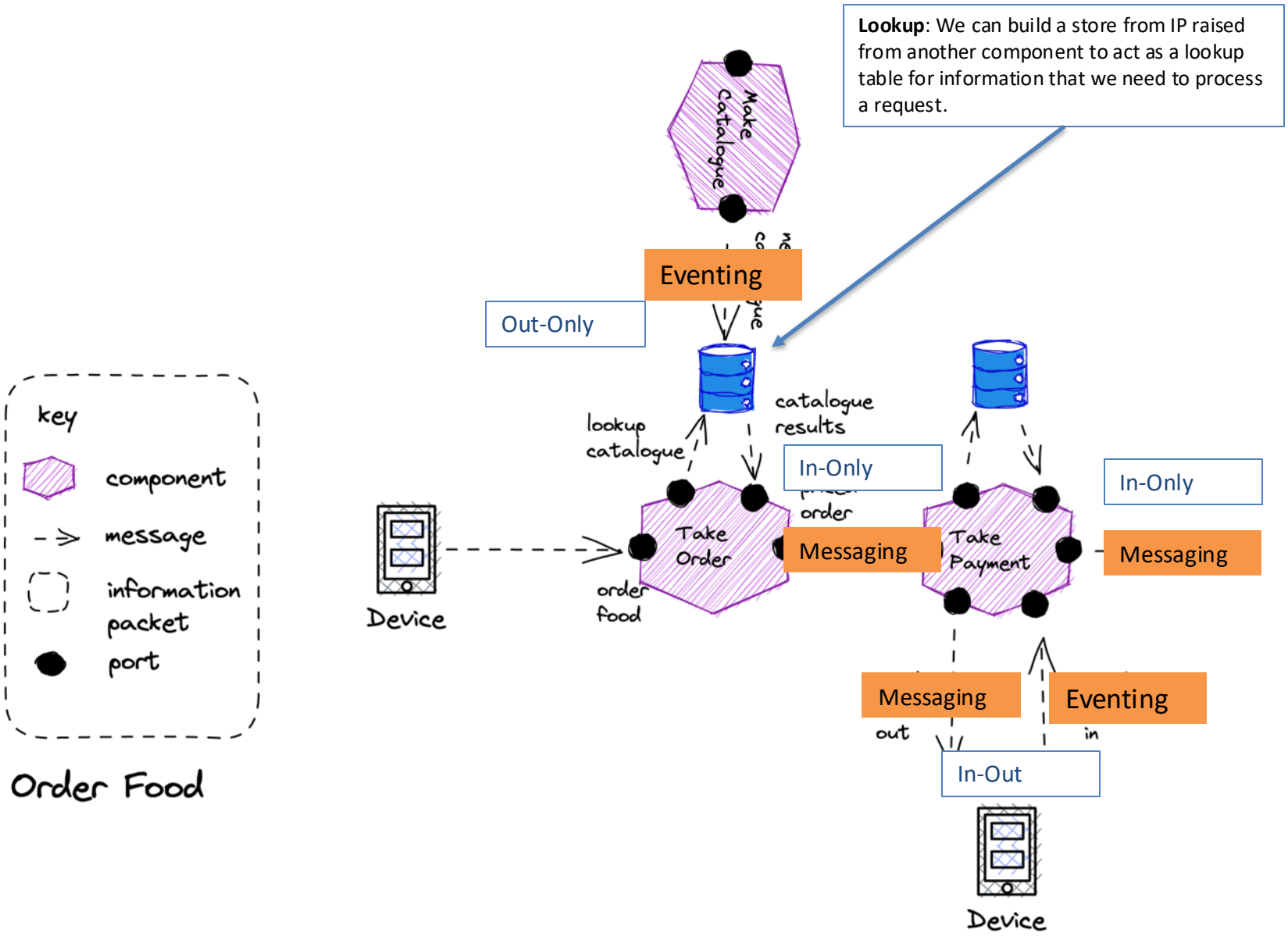


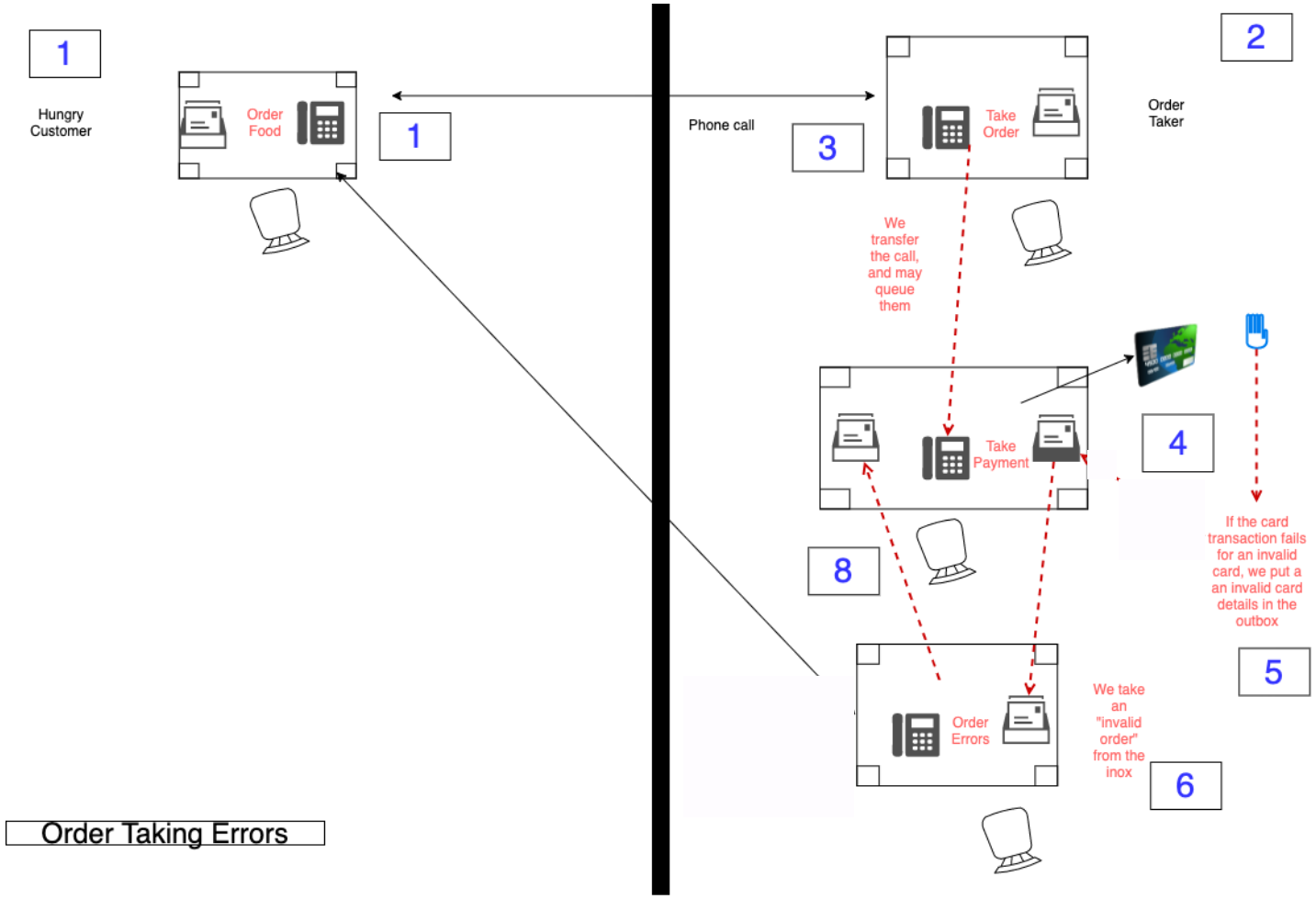
Flow Based Programming - 2010 Update
(J. Paul Morrison)

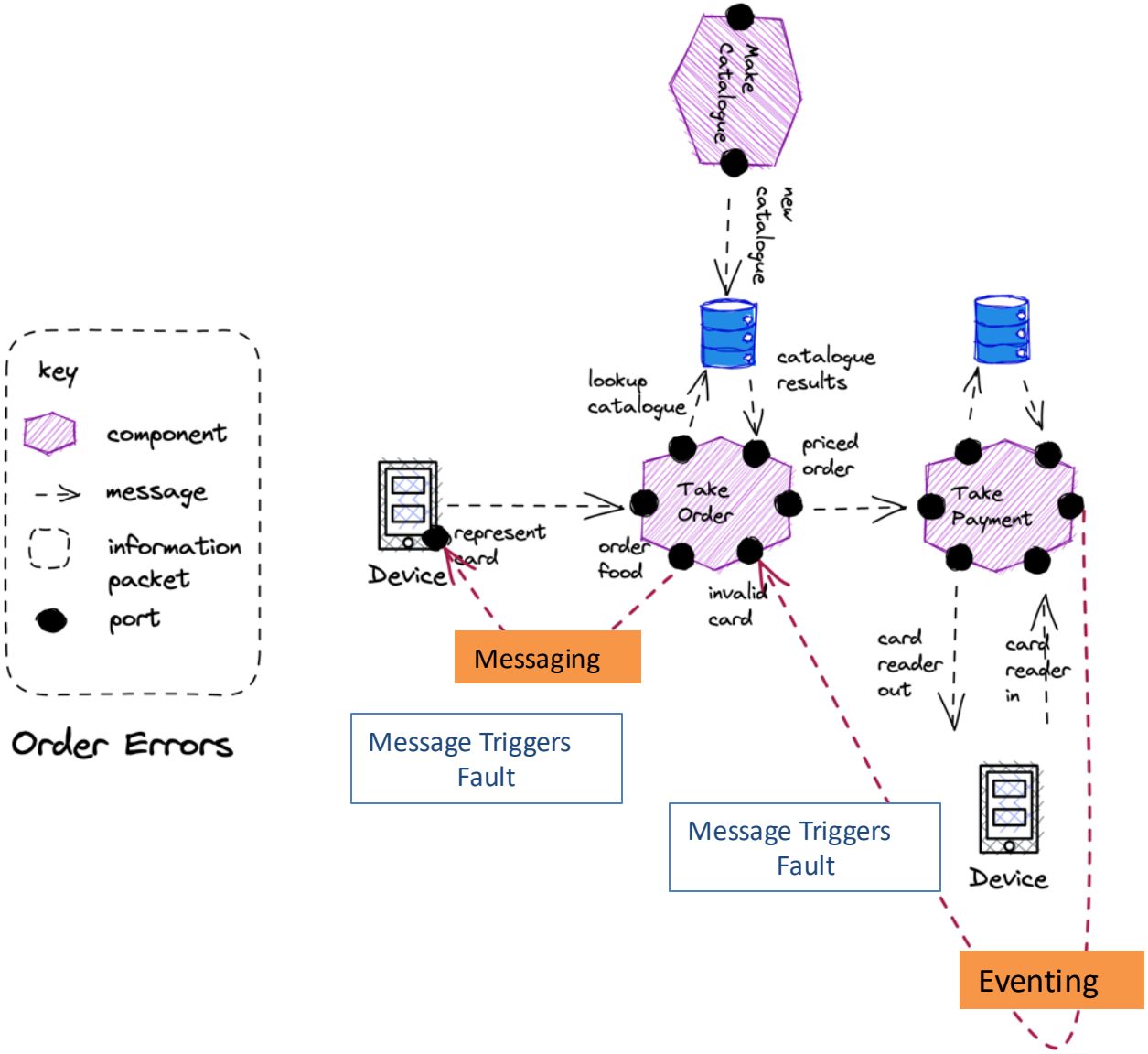

1
Restaurant Owner
Use Just Paper Takeaway
Phone call
2
Sell our Service
Put Request for Details in Outbox
Sales Team
4
Take Request from Inbox
Put Request Menu Outbox
Create Menu Request
Fax Operator
Request Restaurant Menu
Take Request from Inbox
3
Process Menu Request
Put Request Menu Details in Outbox
Fax Operator
7
Take Completed Menu Request from Inbox
Respond with Restaurant Menu
6
5
Chef
Take Request Menu Inbox
Process Menu Request
Put Completed Menu Request in Outbox
New Catalogue
Let's simplify and ignore things like reprographics, we just want to show that this produces a new catalogue.
8
Update Catalogue
Take new Menu from Inbox
Catalogue Maker
9
Restaurant Onboarding

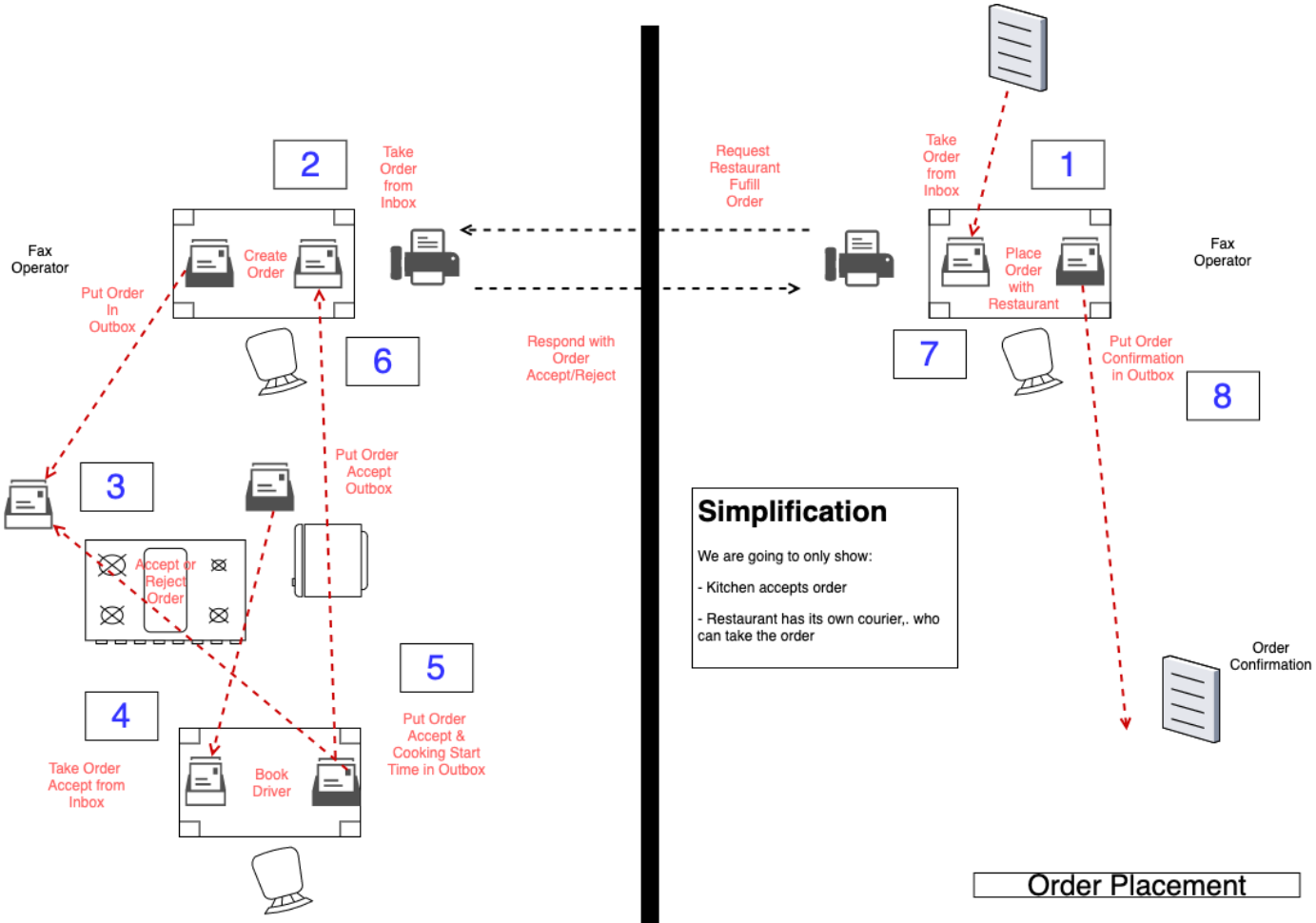

Storage: Request details may need storage to be reliable, it takes work from the request_details port, but cannot forward it to the restaurant_details port without waiting for an answer from fax_in. We store the state of the workflow in case we crash before receiving the response.
Device
key
component
message
information packet
port
onboard restaurant
in-Only
qualified restaurant
Qualify Restaurant
Messaging
request details
Request Details
In-Only
restaurant details
Messaging
add_to catalogue
Make Catalogue
Out-Only
new catalogue
Eventing
fax out
Messaging
Eventing
In-Out
Correlation: To allow us to match the response to the saved state we use a correlation id. We send it on the ip to fax_out, and the restaurant includes it on the ip from fax_in. We use the ip to look up the workflow we stored.
Onboard Restaurant

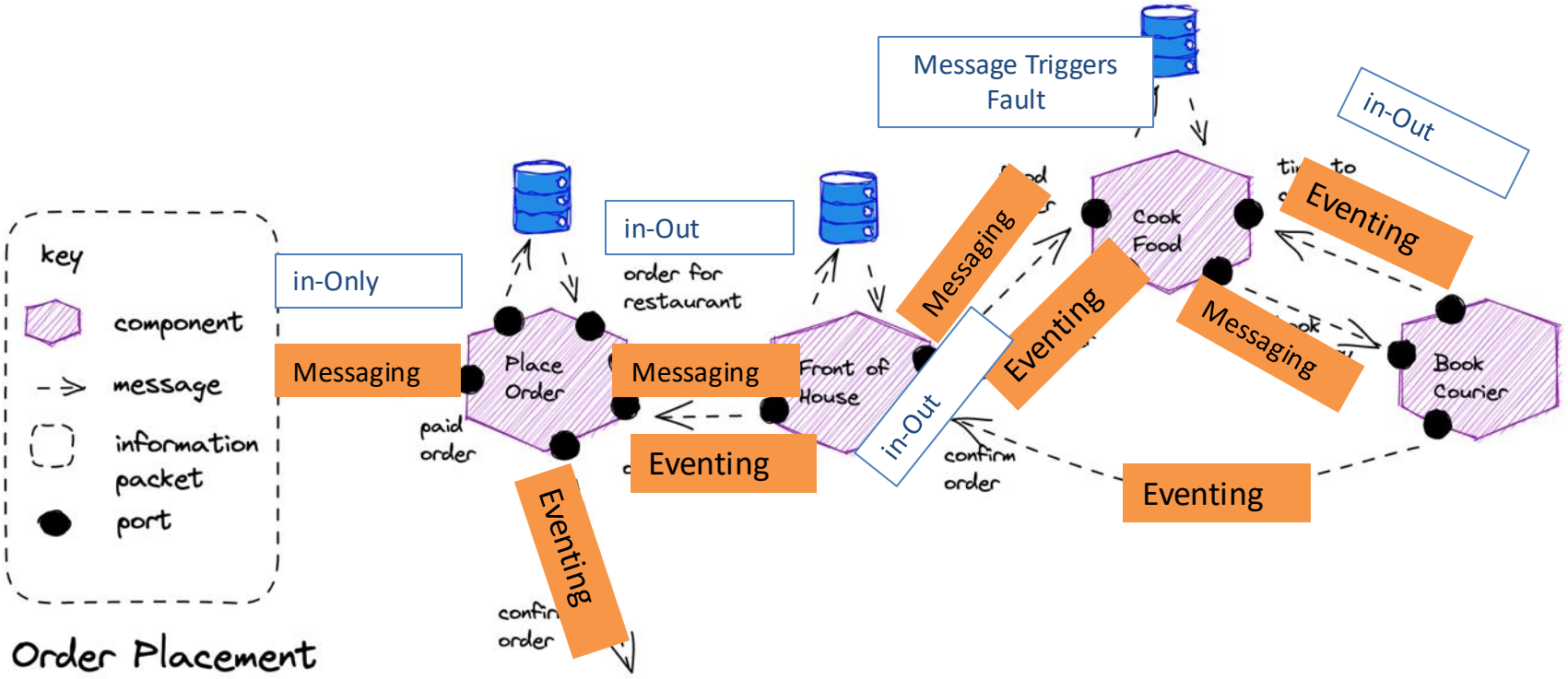

1
New Catalogue
To make a selection, we use the menu, so that we don't need to phone the restaurant to ask what food is available
Hungry Customer
Order Food
2
Phone call
3
New Catalogue
To validate and price the order, our team uses the catalogue, so they don't have to phone the restaurant.
1
When we take an order we validate and price for delivery
Order Taker
Take Order
We transfer the call, and may queue them
Eventual Consistency?
Sometimes customers have an out-of-date catalogue - so we have to validate their order against our latest catalogue
4
Take Payment
5
Operator uses a card machine with cardholder not present
When we take an order we validate and price for delivery
Order
At this point we have a valid order, now we need to get one of our restaurants to cook it!
6
Order Taking

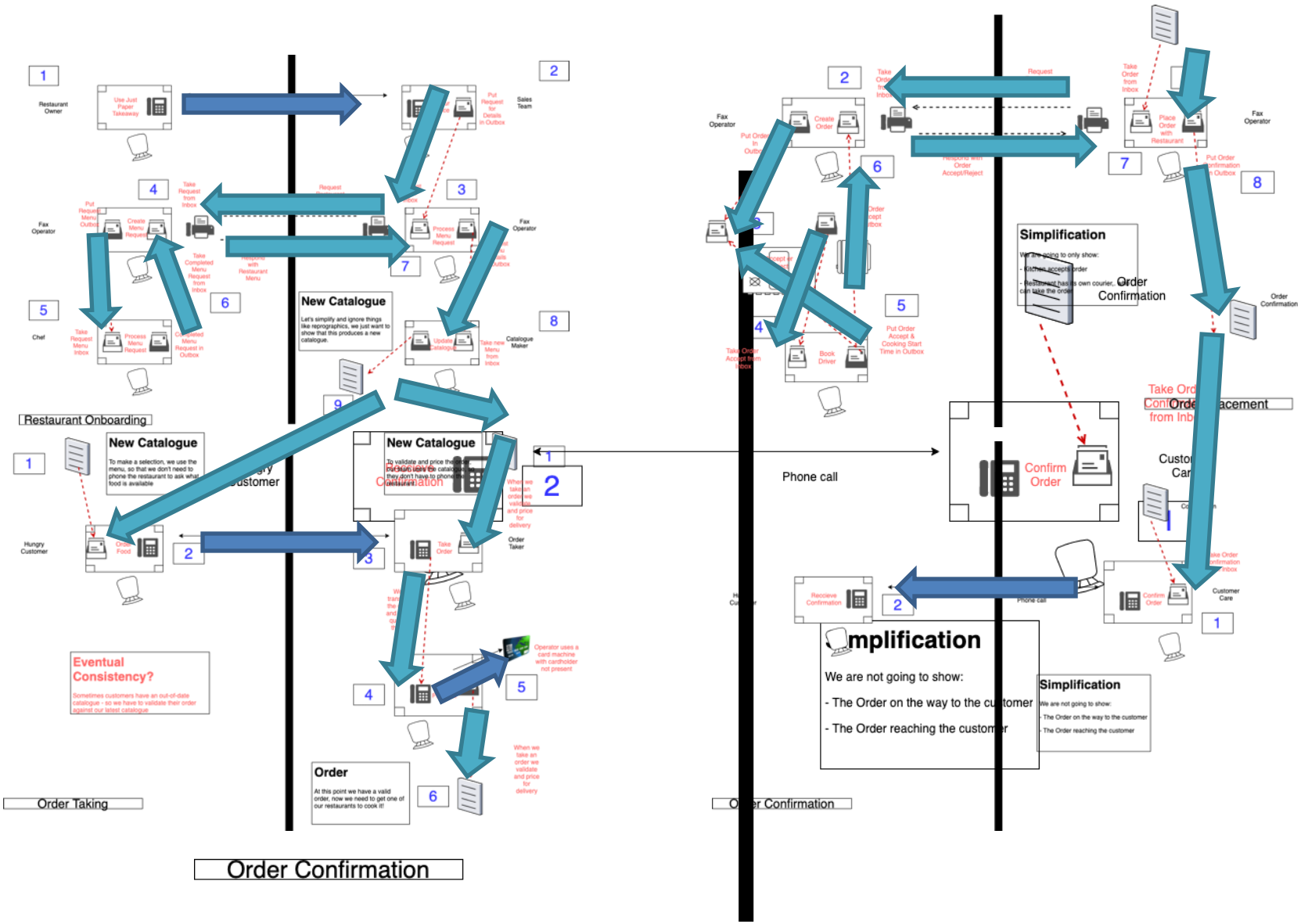

Lookup: We can build a store from IP raised from another component to act as a lookup table for information that we need to process a request.
Make Catalogue
Eventing
Out-Only
lookup catalogue
catalogue results
In-Only
order
Take Order
Messaging
order food
Device
Take Payment
In-Only
Messaging
Messaging
Eventing
out
in
In-Out
Device
key
component
message
information packet
port
Order Food

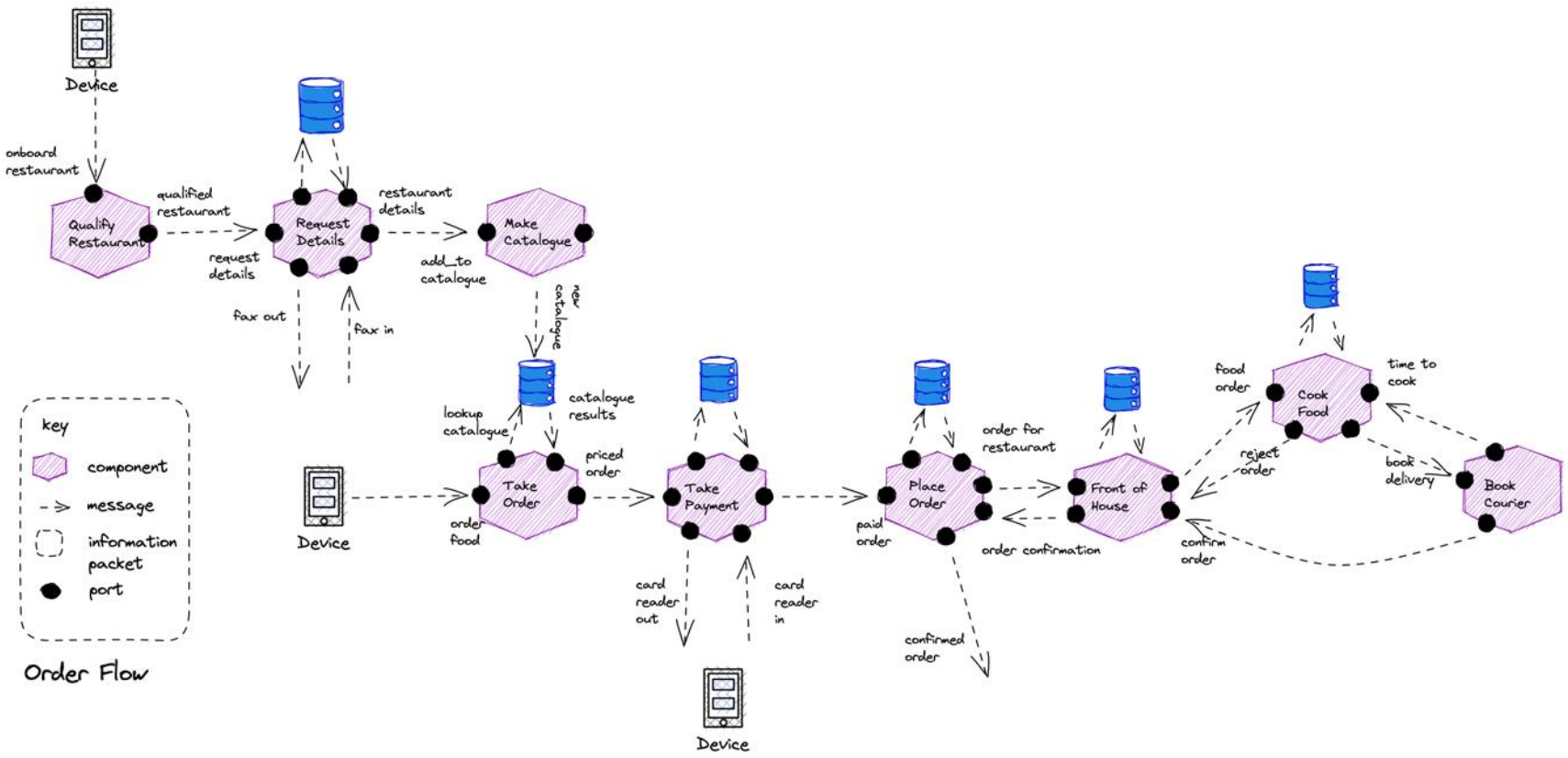

1
Hungry Customer
Order Food
1
Phone call
3
2
Take Order
Order Taker
We transfer the call, and may queue them
Take Payment
4
If the card transaction fails for an invalid card, we put a an invalid card details in the outbox
5
8
Order Errors
We take an "invalid order" from the inox
6
Order Taking Errors


key
component
message
information packet
port
Order Errors
Make Catalogue
new catalogue
lookup catalogue
catalogue results
priced order
Take Order
Take Payment
represent card
Device
order food
invalid card
card reader out
card reader in
Device
Messaging
Message Triggers Fault
Message Triggers Fault
Eventing


2
Take Order from Inbox
Request Restaurant Fufill Order
Take Order from Inbox
1
Fax Operator
Create Order
Place Order with Restaurant
Fax Operator
Put Order In Outbox
6
Respond with Order Accept/Reject
7
Put Order Confirmation in Outbox
8
Put Order Accept Outbox
3
Accept or Reject Order
Simplification
We are going to only show:
- Kitchen accepts order
- Restaurant has its own courier,. who can take the order
Order Confirmation
5
4
Put Order Accept & Cooking Start Time in Outbox
Take Order Accept from Inbox
Book Driver
Order Placement


Message Triggers Fault
in-Out
Eventing
Messaging
Eventing
Messaging
in-Out
Eventing
in-Out
order for restaurant
Messaging
Messaging
Eventing
Eventing
Eventing
in-Only
key
component
message
information packet
port
Place Order
Front of House
Cook Food
Book Courier
paid order
confirm order
Order Placement


Restaurant Onboarding
New Catalogue
Let's simplify and ignore things like reprographics, we just want to show that this produces a new catalogue.
New Catalogue
To make a selection, we use the menu, so that we don't need to phone the restaurant to ask what food is available
New Catalogue
Eventual Consistency?
Sometimes customers have an out-of-date catalogue - so we have to validate their order against our latest catalogue
Order
At this point we have a valid order, now we need to get one of our restaurants to cook it!
Order Taking
Order Confirmation
Phone call
Confirm Order
Simplification
We are not going to show:
- The Order on the way to the customer
- The Order reaching the customer
Order Confirmation


Device
onboard restaurant
Qualify Restaurant
qualified restaurant
Request Details
request details
restaurant details
Make Catalogue
add_to catalogue
new catalogue
fax out
fax in
lookup catalogue
catalogue results
Take Order
order food
priced order
Device
Take Payment
card reader out
card reader in
Device
paid order
Place Order
confirmed order
order for restaurant
order confirmation
Front of House
food order
Cook Food
reject order
time to cook
book delivery
Book Courier
confirm order
key
component
message
information packet
port
Order Flow

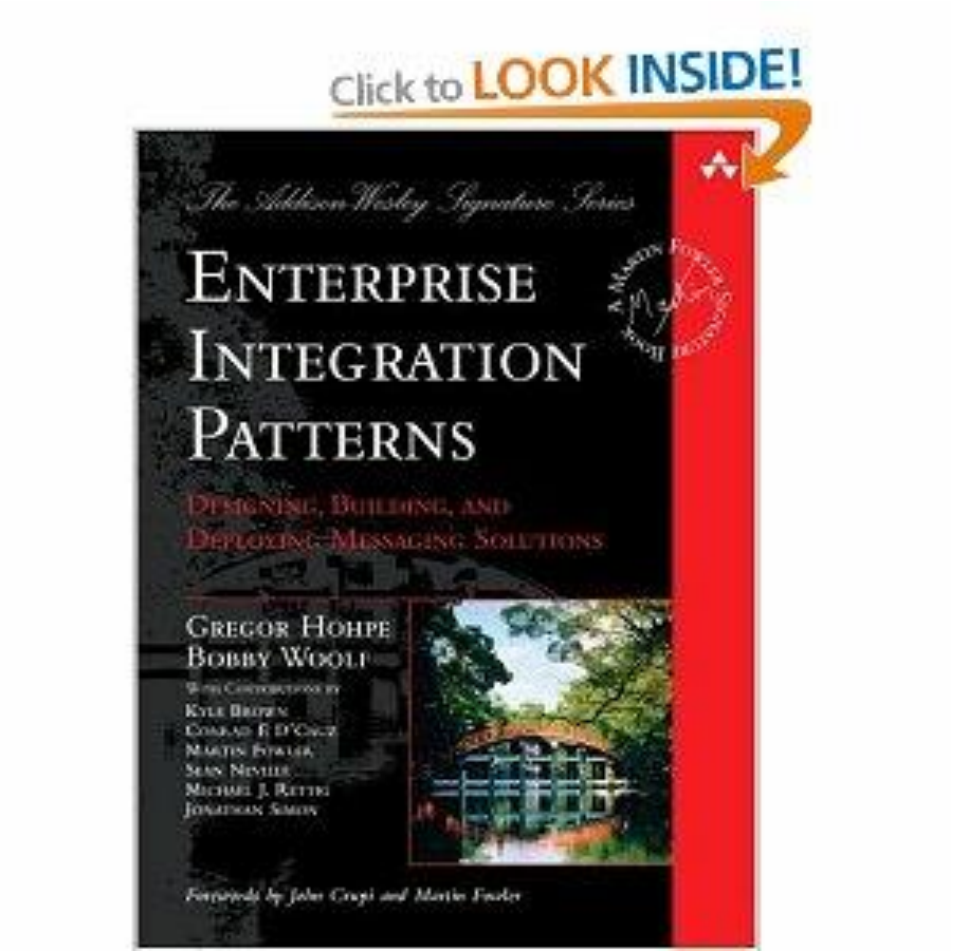
EXERCISE MATERIAL

Paper Flow

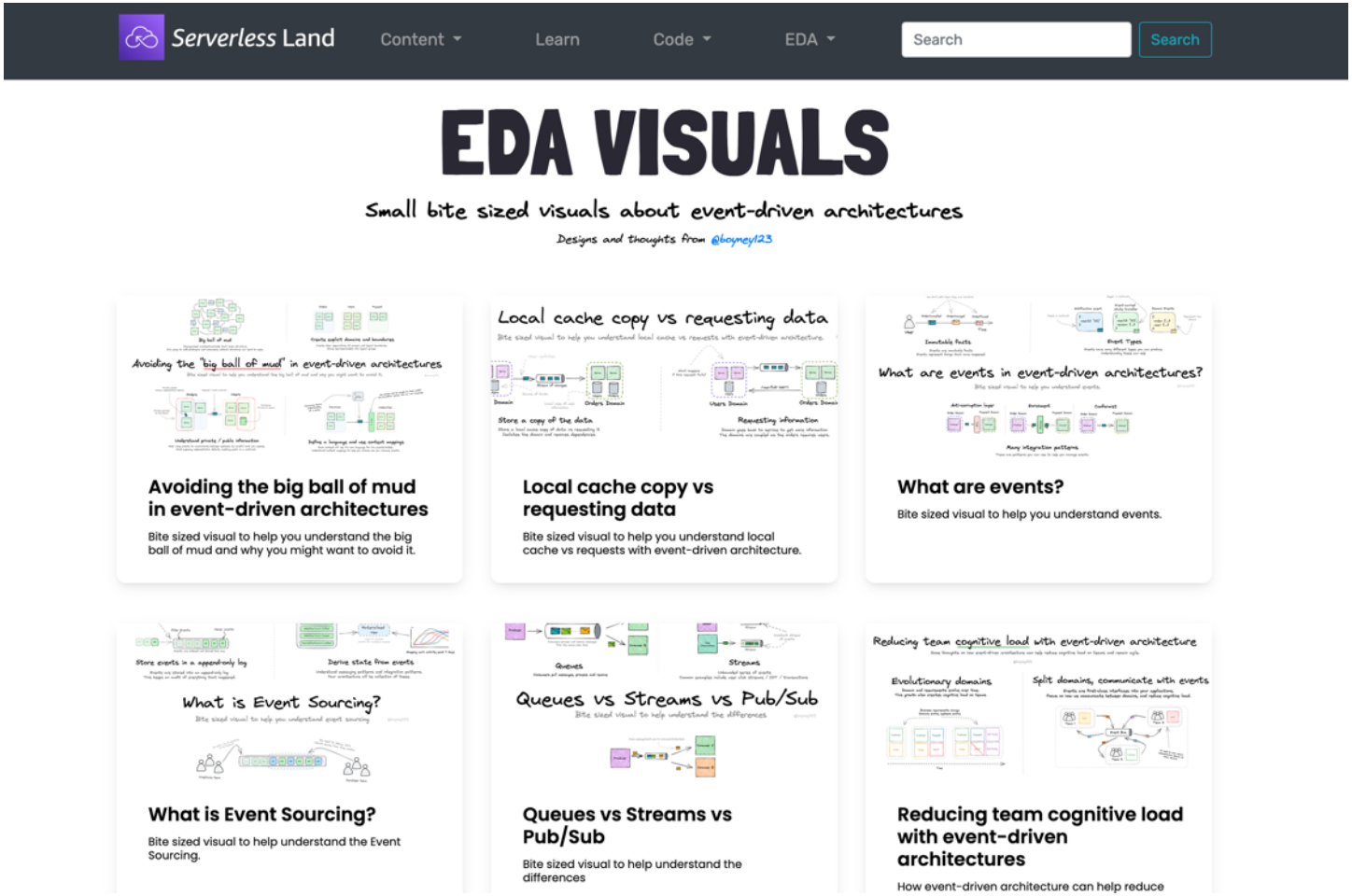
- Readme
- Slides

NEXT STEPS

Further Reading



Further Reading



https://serverlessland.com/event-driven-architecture/visuals

Q&A