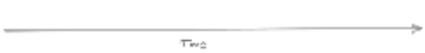
Internal vs External Events

Internal vs External events? Integration Events? Public language? What does it all mean?

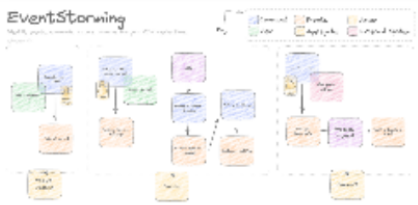
Claim check pattern

Store data into DB, then enrich downstream using key.



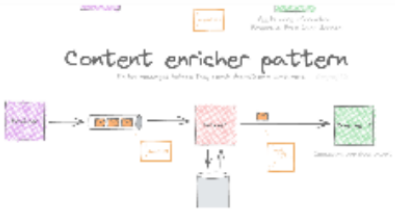
Journey to event-driven architecture

Store data into DB, then enrich downstream using key.



EventStorming

Workshop to identify events, domains, commands and aggregates



Content enricher pattern

Enrich data before it reaches downstream consumers

Document your event-driven architecture

Notes, thoughts and examples of how to document your event-driven architectures.

EDA VISUALS

Small bite sized visuals about event-driven architectures

Event first thinking

Identifying events and designing them is important.

Good and hard parts of EDA

Event sourcing and change data capture to for applications.

Event Types

Different types of events used in EDA

Message Queues vs Event Brokers

Understanding queues and pub/sub

Ubiquitous Language

Define a shared language across the business

Commands vs Events

What are commands? What are events?

Event-driven architecture notes by David Boyne

EDA Visuals: Small bite sized visuals about event-driven architectures

David Boyne

v0.0.31

About EDA Visuals

I started EDA visuals as way to share my thoughts, notes and designs with others online. I'm currently using Zettelkasten note taking methods to find information and connections between research. Everything I learn is shared in public, and this document shares some of these thoughts and notes with some visuals to help (myself) and hopefully you too.

This document is organic, every time new visuals are uploaded online this document will be generated and uploaded. (so make sure you keep coming back to check for updated versions).

I truly believe event-driven architectures can transform organisations and I hope you find these notes and visuals useful.

David Boyne

About David Boyne

My name David Boyne and I'm a Developer Advocate at AWS focusing on event-driven architectures and serverless technology. I dive deep into event-driven architectures and create content online to help others. I have also created many open source projects to help you manage event-driven-architectures (e.g. https://eventcatalog.dev).

If you want to learn more or keep up to date with updates feel free to connect with me.

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- LinkedIn: https://www.linkedin.com/in/david-boyne/
- GitHub: https://github.com/boyney123
- Website: https://www.boyney.io/
- My Open source projects: https://www.boyney.io/projects

Speaking at Events

If you are interested in having me speak at your upcoming events, I would be happy to discuss the possibility. Whether it's a conference, podcast, seminar, workshop, please feel free to contact me.

Thanks for downloading this content, I hope it can help.

Table of Visuals

Agility with event-driven architecture

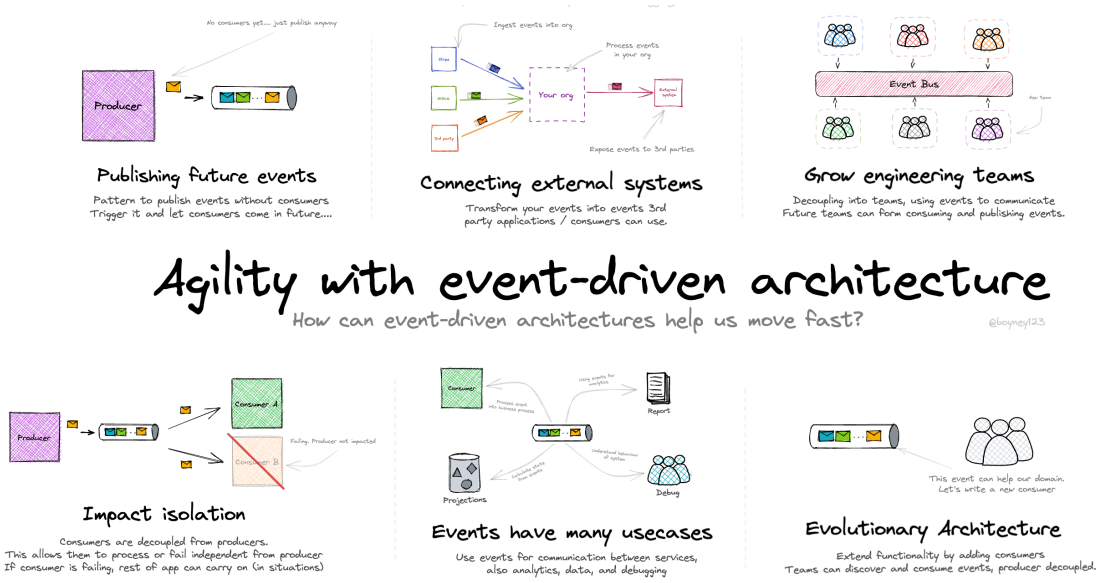


Figure 1: Agility with event-driven architecture

Event-driven architectures provide agility to engineering teams and organisations. Let's dive into more details about how and why.

Evolutionary Architecture

- Common saying with event-driven architectures, is that **producers do not know about consumers**, this allows consumers to be disconnected to producers.
- Without the coupling of producer and consumer, consumers can come and go easily.
- As business requirements change, we can add or change consumers without impacting producers or other parts of our architecture.
- Discoverability is important for consumers to know what they can subscribe to, documentation can help here.

Grow engineering teams

- Using events to communicate between teams/domains is a popular way for engineering teams to scale.
- Event-driven architectures allow us to remain decoupled, and evolve and adapt teams to meet business requirements/features.

- Event-driven architectures couple with domain driven design very well. Define boundaries in your organisation and create teams around that. Understand how Conway's law can impact this.

Connecting external systems

- Event-driven architectures are not just about the events we raise internally within our business or organisation, but events we can also consume and share with others.
- Modern applications integrate with external systems all the time, consume events from other applications and process them internally (webhooks common pattern)
- Expose events to other consumers outside your domain/business, can also provide value.
- Bi-directional events are powerful, reacting to real-time events, processing them and passing them back to the business that produced them.

Impact isolation

- Producers are often disconnected from the consumers, if consumers fail then impact is isolated.
- Event-driven architectures can give availability as components/services are isolated and use events to communicate.
- When consumers fail you have options to deal with this. Having idempotent consumers help, without them you may run into strange side effects.

Publishing future events

- Some producers may publish events into the architecture even if no downstream consumers are listening to them.
- If you know your event is valuable to the organisation, you may want to publish it and have the option to listen in the future.
- If you use this pattern, maybe consider the costs in doing this, does your broker charge for events published?

Extra Resources

- Flow Architectures - Great book by James Urquhart about how events can and will be used to communicate between organisations.
- Bidirectional events example - Connecting organizations and events, here is an example of how Amazon EventBridge explore bidirectional events with Salesforce. Some interesting patterns here.
- Dive more into domain-driven design with EDA - Event-driven architectures, team topologies, domains? What does it all mean? Here is a visual to help you.
- How does pub/sub work in EDA applications - Want to know more about pub/sub patterns, producing events for downstream consumers with a fan out approach. Resource here to help.
- Conway's law and EDA - Our system is a reflection of the teams that build it. What does that mean for our EDA solutions? This visual can help.

Avoiding the big ball of mud in event-driven architectures

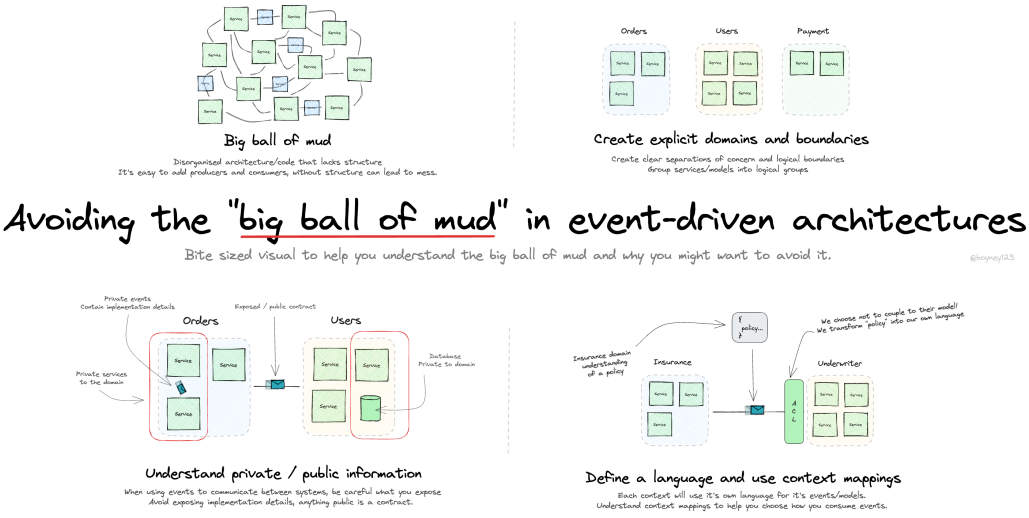


Figure 2: Avoiding the big ball of mud in event-driven architectures

When building event-driven architecture your architecture will evolve, you will add more producers/consumers as time goes on. Without any design consideration you can easily end up with a "big ball of mud".

"Big ball of mud" refers to an architecture that lacks structure, models within services become unclear, and it's hard to iterate as there is no clean boundaries within the system. When you have a free for all with consumers / producers it can become easy to fall into this type of architecture over time.

To remain agile, resilient and have an architecture that remains loosely coupled, avoiding a big ball of mud can help.

Big ball of mud

- Architectures grow to the point they have unclear boundaries.
- Models are unclear within the architecture, hard to understand and change.
- Architecture can turn into a spaghetti code mess.
- With event-driven architecture it can become quite easy to fall into this type of architecture.

Create explicit domains and boundaries

- Event-driven architecture and domain-driven design (DDD) work very well together. With DDD practices we can identify our boundaries, core and subdomains within our architecture.
- A great way to do this with event-driven architectures is to explore Event Storming or Event Modeling and a tool to help you identify your logical boundaries.
- You want to work with domain experts to identify these boundaries and start to communicate a common language used.
- Having these boundaries makes it easier to manage and gain an understand of your architecture.

Understand private / public information

- When you have your boundaries there will be information / services / events that you may want to keep private within this domain.
- Private events tend to be events you use to communicate between services within a boundary. The contract of these events are different to events that are "public". It's less risky to put implementation details within these events, as the services within the boundary may understand the details (better than other services outside).
- Public information or events is information you want to share with other boundaries. These contracts are important, and it's important not to expose too much (or if any) implementation details within your boundary. These event contracts are important, and some up front design of these events can help.

Define a language and use context mappings

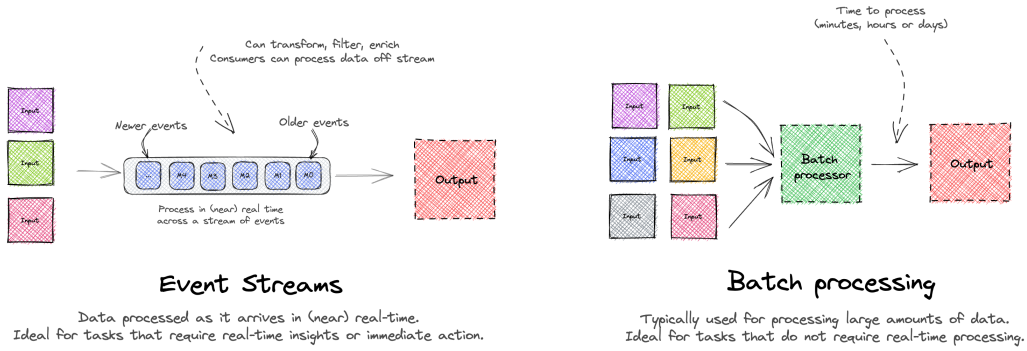
- Each boundary will have its own common language (ubiquitous language), embrace that and understand that, things become easier once you identify this.
- When communicating with events (or APIS etc) it's important to understand context mapping options you have. Do you want to consume as it is and be bound by the contract (Conformist), do you want to transform the message into something you can understand (anti-corruption layer), do you want to agree on a public language (open-host service), do you want to work even closer together (consumer-supplier relationship). Depending on what you want depends on what context mapping option you may explore.
- Consuming an event as it is, you are conforming to that contract. This is the default behaviour, you may or may not want to do this, but it's worth noting and thinking about.

Extra Resources

- Event-driven architecture with domain driven design - I visual I created to help you understand why EDA and DDD work so well together, and extra resources to help you dive deeper.
- What is Event Storming? - Another visual to help you understand Event Storming with extra resources. A great tool to help you identify domains within your systems.
- Internal vs External events - Visual here to help you understand internal and external events.

- What are bounded contexts? - Here I dive into bounded context to help you understand what they are.
- Messages with bounded context - Dive deeper into context mappings with events.
- Learning Domain Driven Design - Some notes in this visual were taken from the book “Learning Domain Driven Design” by Vladik Khononov.
- Domain-driven design distilled - A nice book by Vaughn Vernon that gives a great overview of domain-driven design. This visual was inspired by notes in that book.
- Domain Driven Design and Event-Driven Architecture Podcast - Vaughn Vernon gives a podcast that dives into EDA and DDD. If you want to dive deeper worth a listen.

Batch processing vs event streaming



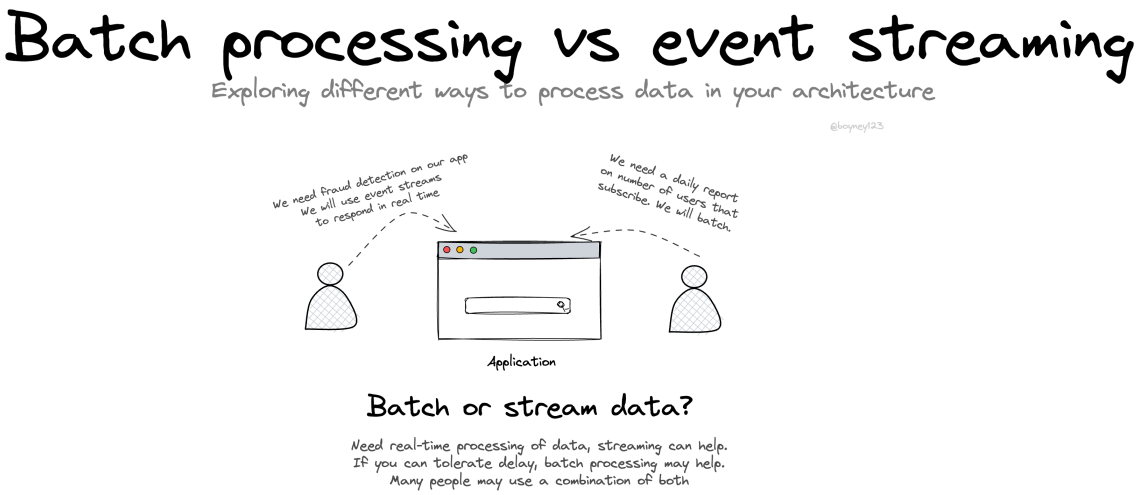


Figure 3: Batch processing vs event streaming

As data becomes an increasingly important part of modern businesses, organizations often find themselves needing to process large amounts of data. Two common approaches to processing data are **batch processing** and **event streams**.

Batch processing

- Batch processing involves processing data at once usually during a scheduled time interval such as daily or weekly.
- Commonly used for tasks that do not require real-time processing and tasks that can tolerate some delay.
- Great if you have a fixed set of input data you want to process.

- Example of batching would be AWS Batch or Apache Spark

Event streaming

- Event streams involve processing data as it happens. Event streams are a continuous flow of data that can be collected and processed in (near) real time.
- Commonly used for applications that require real-time insights. Example of this could be fraud detection, or real-time recommendations.
- Processing data in real time gives organisations information they can act on and analyse straight away, done right this could provide a competitive edge to your business.
- Events can be unbounded data (continuous data, or never ending), so if you need to process this kind of information in real-time then streaming can help.
- Example of streaming would be Amazon Kinesis or Apache Kafka

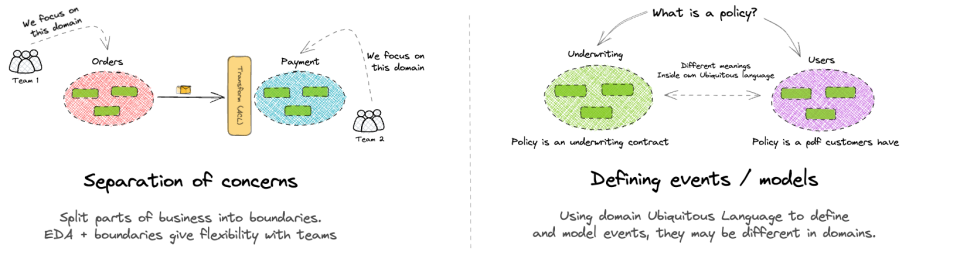
When to use batching or event streaming?

- Like always, depends on your use case. Can your data processing tolerate some delay? Then maybe batching might be a better fit. Do you need to process the data right now? Will you have an advantage to processing information straight away? Then streaming events might make more sense.
- Remember to consider the costs between batching options and streaming options.
- Use patterns to help your downstream consumers. Remember with streaming and batching you can apply integrations patterns during that particular phase. Example would be enriching events/messages as they go through your stream for downstream consumers.

Extra Resources

- Designing data-intensive applications - Book has some great insights into batching and streaming. Recommend reading.
- Understanding event streaming - Dive deeper into event streaming with this visual.

Bounded context with event architectures



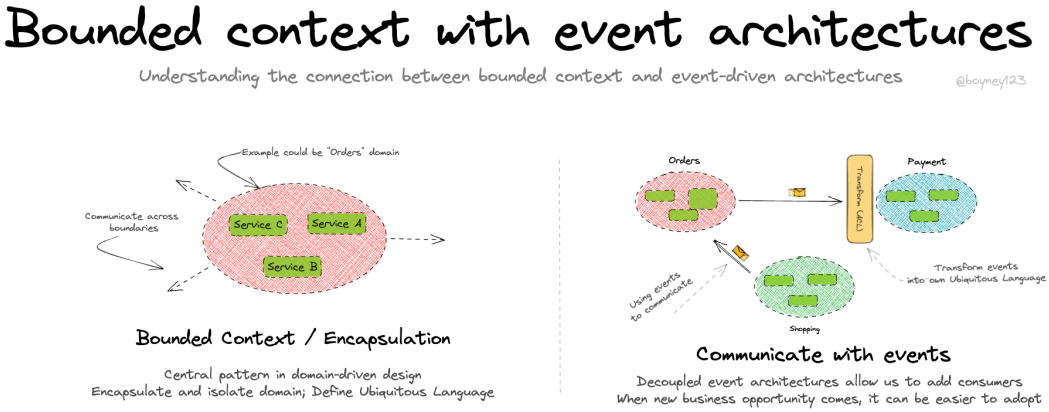


Figure 4: Bounded context with event architectures

Bounded Context

- A central pattern in domain-driven design
- A contextual boundary as part of your domain.
- Has it's own set of concepts and it's own Ubiquouts Language.
- Provides a way to isolate and encapsulate parts of your system
- Great pattern to define boundaries for event-driven architectures
- Common patterns are to use events to communicate between boundaries.

Defining events / models

- Each boundary has its own language, use this language to define events and schemas within your boundary.
- You may have internal and external events within a boundary. External events may be used to communicate with other boundaries.
- Models may differ from boundaries, it's important to understand different context mapping patterns you can use to transform events/messages before consuming them.

- **Consuming an event directly into your boundary** could couple you to the model of another boundary, think about that before you do it.

Communicate with events

- Event architectures allow us to define producers and consumers, theses producers and consumers can live across boundaries in your system, and event-driven architectures give us a great ability to communicate between these systems.
- If you follow domain-driven design practices with clear boundaries, you will have decoupled areas of your system, event architectures are a great way to keep decoupled, these go hand in hand.

Separation of concerns

- A big benefit of event-driven architectures is they allow us to be decoupled. This means changes to consumers have limited impact on other consumers/producers.
- If you have clear boundaries in your system and use event-driven architectures to help you can start to form a clear separation of concerns for your organisation and tech teams, allowing to scale solutions and teams faster.

Extra Resources

- Good and hard parts of EDA - Understand the good and hard parts of EDA, defining clear boundaries is just part of the whole picture, it's important to explore more.
- What is Ubiquitous Language? - Visual here to help you understand what Ubiquitous Language is, and why it's important.
- Transforming data between boundaries - When you consume events/messages between boundaries you may not want to take it as it is (raw), do you want to translate the data into your own domain? The answer, probably yes.
- Internal and external events - Firing events within your boundary, firing events outside? Integration? What does it all mean?

Choreography vs orchestration

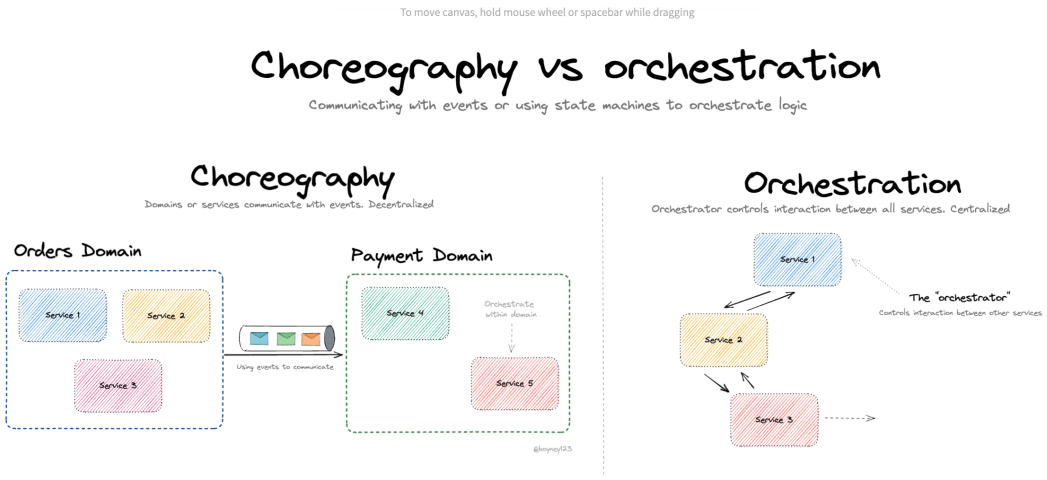


Figure 5: Choreography vs orchestration

Choreography Using events to talk between services (also bounded contexts). Services interact independently. Event-driven approach.

Example of services that can help with choreography are Amazon SQS, Amazon SNS or Amazon EventBridge.

Orchestration Flow of state that is normally controlled by the orchestrator. Think of flow chart or state machines. Might consider using orchestration within a bounded context. Normally follows request/response.

Example would be AWS Step Functions.

Extra Resources

- Choreography vs Orhestration in the land of Serverless - Great blog on choreography and orchestration through a serverless lense.

Claim check pattern

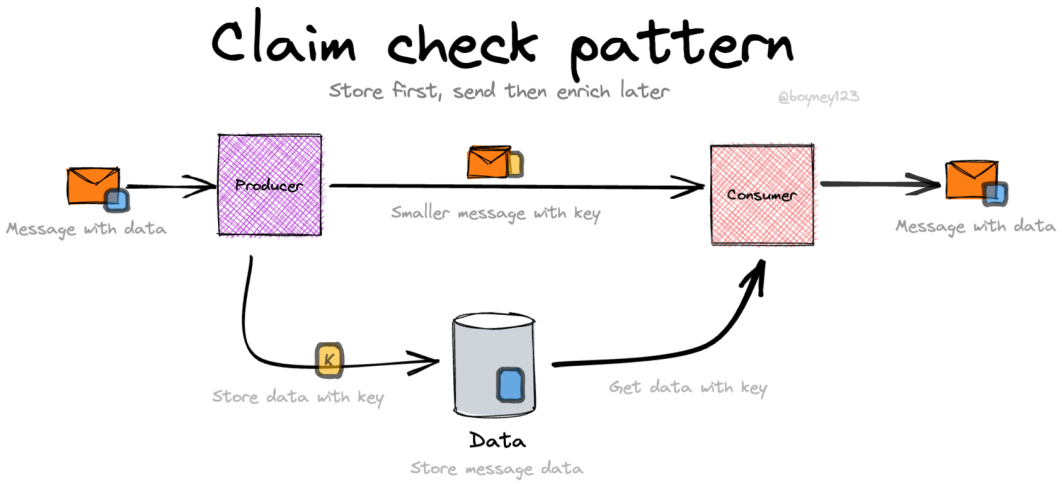


Figure 6: Claim check pattern

Sometimes you may want to store information first, and then send message downstream to consumers. This allows you to offload data or large events into a database and then send lighter events downstream.

An example use-case of this pattern would be to send large payloads (exceeding your event broker limits) to downstream consumers. First you store, then you use the key downstream to get the information back from the database.

Extra resources

- Claim Check Enterprise Integration pattern - Enterprise integration pattern for claim check, if you want to know more head here.
- Publish large EventBridge events with the claim check pattern - Blog post that I wrote, to help you use the claim check pattern with Amazon EventBridge.
- Code example using S3 and EventBridge - Pattern to show you how to use S3 and EventBridge with claim check

Commands vs Events

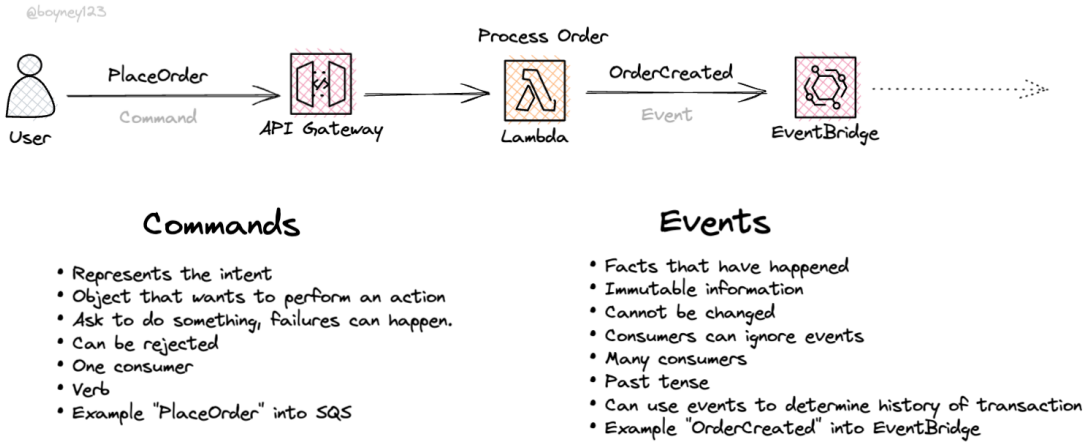


Figure 7: Commands vs Events

Understanding the difference between commands and events can be important when building event-driven architectures.

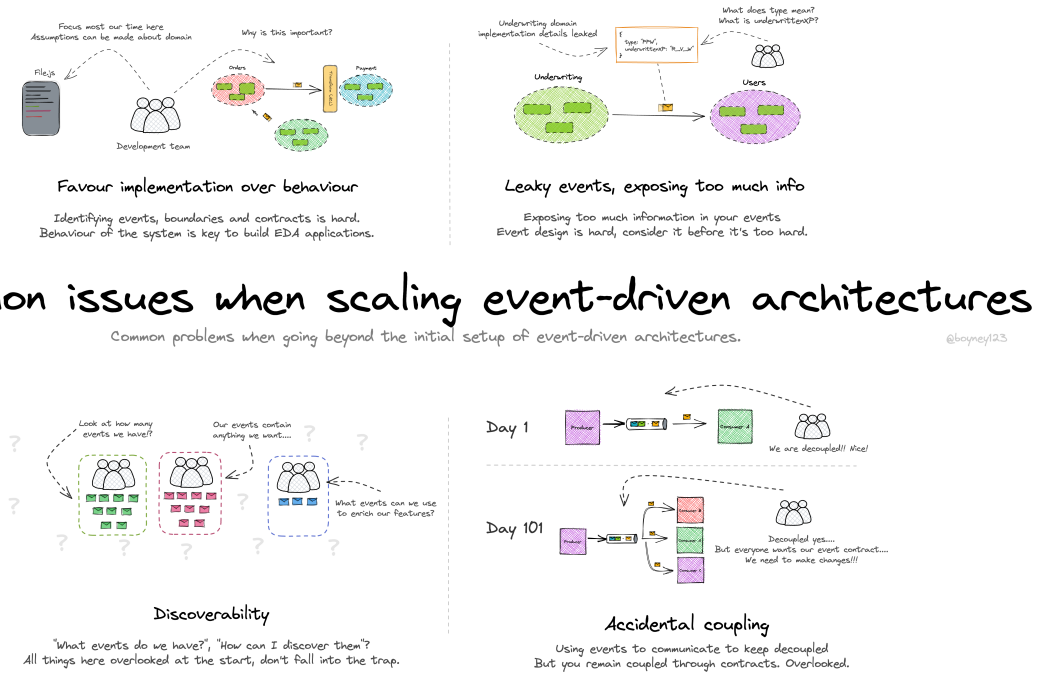


Figure 8: Common issues when scaling event-driven architectures

Talking to many folks in the community there seems to be shared problems that occur when you scale event-driven architecture solutions within your organisation.

Starting with a few producers/consumers can be great, but without considering a few fundamentals you may end up in the same place many others do, looks explore some of of these common issues.

Discoverability

- Events are added over time, 10s, 100s or 1000s. All flying through your architecture
- Many events can have many consumers, knowing **who is consuming events can help**
- Many people scale events, but **don't keep track on who is consuming what**. This can lead into event management issues (changing events, schemas etc).
- Many folks want to consume events to enhance, their functionality. But where can they find events in your system? Are they documented somewhere? Probably not?
- Event based architectures are super powerful and can help us scale and be decoupled, but without governance, standards and discoverability you will end up lost, who is coming what!? Can we change this field?

- Ways to help, documenting your events, explore tools and solutions that can help. (visual to help)
- Think about this up front, 2 years from now how will people discover your events?

Accidental coupling

- So, you are building event-driven architectures, using events to communicate between systems, you are decoupled? Maybe not.
- It's important to remember **we are still coupled by the event contract itself**; consumers rely on the contract of the event and schema (often overlooked).
- You have many ways to create events (e.g. notification, stateful events), depending on your choice depends on how coupled downstream consumers will be to the contracts.
- Keeping track of who is consuming what can help you make schema/payload changes.
- What is your schema management path? E.g no breaking changes? Forward compliable? Consider, in 2 years how are you going to make changes to these events?
- Making changes to events, do you want to produce two different versions and give time for consumers to migrate, this is a valid pattern that some follow.

Leaky events, exposing too much info

- What goes into your event? Do you just throw anything in? Probably not.
- When starting out it's often overlooked and payloads in events can be anything.
- Take time, think and consider standards in your events.
- Consider your domains and bounded context, consider what information should stay within a domain and what information can be exposed.
- Use a public interface/language between your bounded context and others.
- If you are consuming events, you might want to transform these, before external domain models leak into your domain.
- Spend time here, think about bounded context and the language used within each domain. Be mindful in what you expose.

Favour implementation over behaviour

- It's easy to get carried away with coding implementation details, and overlook the behaviour of the system, knowing what events should be fired when, and what should go inside these events.
- Events can be technical events, but also business level events, everyone having an understanding of your business domain helps (sounds simple right? So many assume they know business behaviours).

- Limit mental translations between teams, be clear on business intent and focus on behaviour then focus on implementation details.
- EventStorming can help identify your domains and bounded context.

Extra Resources

- Types of events - There are many types of events, understanding them can help.
- Learning Domain Driven Design - Some notes taken from the book "Learning Domain Driven Design" by Vladik Khononov.
- EventStorming - EventStorming is a great way to find events and domains, and also go that next level, start to map and shape your schema contracts.
- CloudEvents - A specification for describing event data in a common way. Want to standarise your events, why not use industry standard?
- AsyncAPI - Specification to help you define async APIS and event-driven architectures. Recommend looking into this.
- Amazon EventBridge: Event Payload Standards - Blog post I wrote awhile ago, inspired by community, this is an example of event standards and payloads.

Content enricher pattern

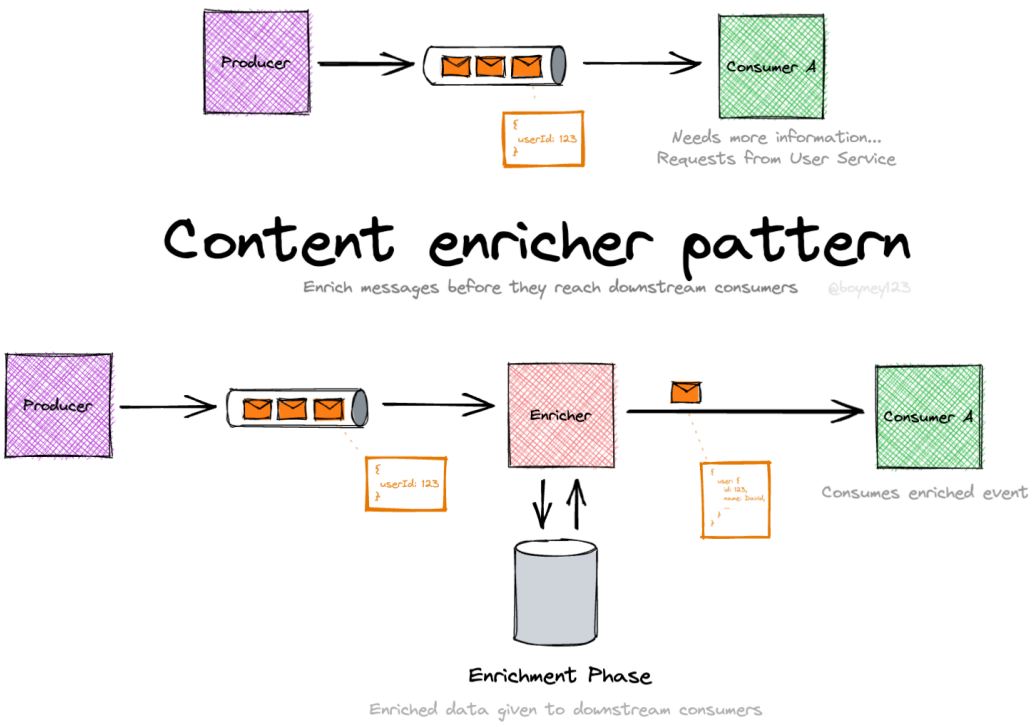


Figure 9: Content enricher pattern

Sometimes downstream consumers need more information (sometimes seen when events are notification events). Downstream consumers call external APIS or back to the producer to get information they require. Be careful with this pattern as it could lead to coupling.

With **content enricher** pattern you can add an **enricher** in the middle to pick up messages/events and enrich them before sending downstream to consumers.

Why enrich messages and things to consider

- Keeping the enrichment outside of the consumers domain, keeping consumer "pure".
- Stop consumers fetching information they require from producer or other APIS.
- Enrichment pattern can lead to more code to maintain and manage
- If consumers need more information, are your event payloads or business boundaries, correct?

Extra resources

- Content Enricher Enterprise Integration Pattern - Great book with tons of patterns and information. Content online for free, recommend reading this.
- Enrich EventBridge events with Lambda - Blog post I wrote about enrichment pattern and using Lambda to enrich your events
- Enrichment pattern with EventBridge Pipe - Pattern that I wrote for ServerlessLand that uses EventBridge Pipes to enrich data before sending to downstream consumers.

Document your event-driven architecture

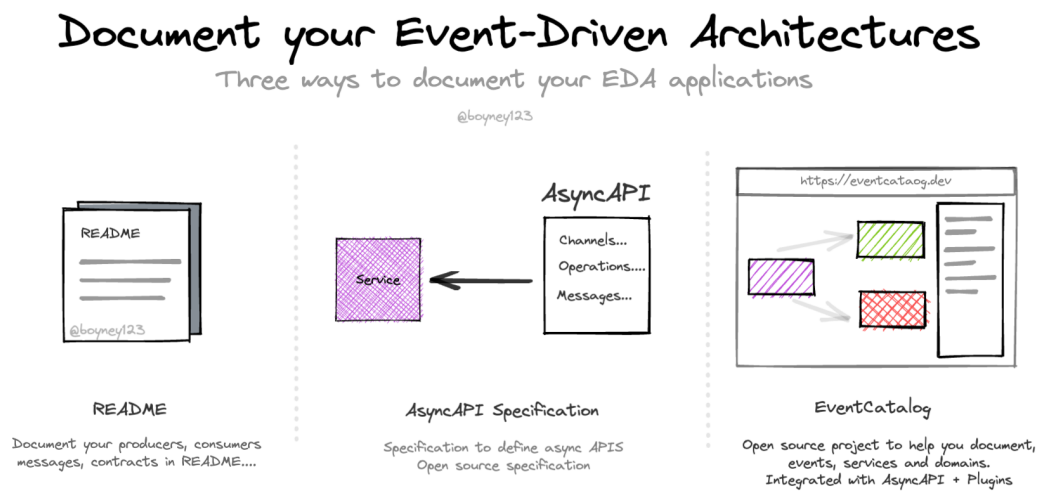


Figure 10: Document your event-driven architecture

When you dive into event-driven architecture you will see one of the main benefits is "loosely coupled" services. In fact many people will say *"producers should not know about consumers"*, this is technically true..... but overlooked.

Technically our *producers should not know about consumers* but operationally as humans we do. Common questions come up when building EDA applications over time:

1. What events/messages is this service producing?
2. What events/messages can I consume from this service?
3. What is the format of these events/messages?
4. What schema version do I use?
5. Who is producing what?
6. Who is consuming what?

These are common questions that will arise when building EDA applications.

Here are three areas that I consider that can help:

Using README files Simple and cheap. If you want to document your schema, or what your service is publishing or subscribing too, maybe readme files can help? Anything is better than nothing. (maybe you think nothing is OK, but as you scale your app high chance you might need some form of discovery)

AsyncAPI AsyncAPI is an open source specification for defining asynchronous APIS. The community has been growing over the past few years and many large organistions using it to help them define and write standards for producers and consumers. Community has a wide range of tools to help with integrating and documentation too.

EventCatalog I'm of course biased here, this is my own open source project called EventCatalog. I designed this to help people document their EDA applications, powered by markdown files and custom plugins. You can connect any system you want to EventCatalog and generate markdown files. This web interface gives your team a new visual way to navigate producers, consumers and domains. See example in action here.

Extra resources

- AsyncAPI - Open-Source tools to easily build and maintain your event-driven architecture. All powered by the AsyncAPI specification, the industry standard for defining asynchronous APIs.
- EventCatalog - EventCatalog is an Open Source project that helps you document your events, services and domains.

Event Types

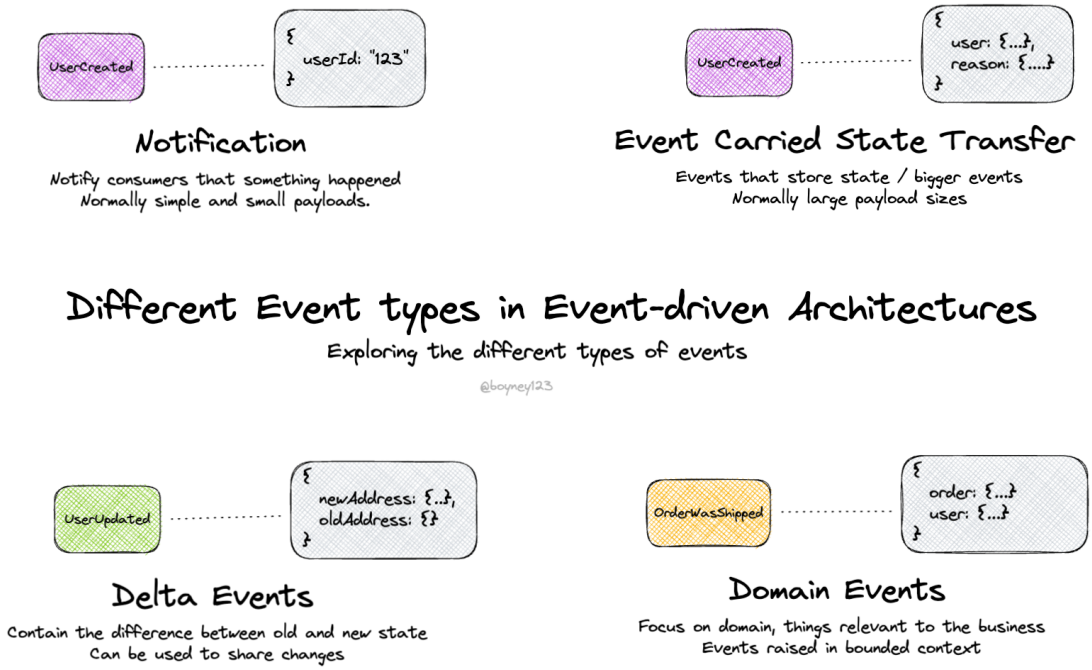


Figure 11: Event Types

When building EDA applications, it's important to know the different types of events you can publish, each has their own trade-offs.

Notification Events

- Minimal information
- Less risk of data being out of sync
- Consumers often need to fetch data
- Increases architecture coupling (callback for info)
- Producer/Consumer contracts kept minimum
- Lower risk of breaking contracts

Event-Carried State Transfer

- Enriched events (stateful)
- Higher risk of data being out of sync
- Consumers have the data
- Decreases architecture coupling

- Producer/consumer contracts more coupled
- Higher risks of breaking contracts

Delta events

- Stores difference between old/new
- Examples seen in change data capture events
- Can reduce complex in consumers needing to figure out what has changed

Domain Events

- Events that raised in the same bounded context
- Some folks reference these as internal events raised in bounded context
- Some folks reference these as business "important" events.
- People also refer to "integration" events. These are events used for integrations.

Extra Resources

- Best practices to design your events in event-driven applications - A talk I gave in 2022 around event design and trade-offs to consider.
- What do you mean by "Event Driven?" - Martin Fowler dives into event-driven architecture and talks about the different types of events
- The Event-Carried State Transfer Pattern - A great blog post on what ESCT is
- The event notification pattern - A great blog post on what notification events are

Event first thinking

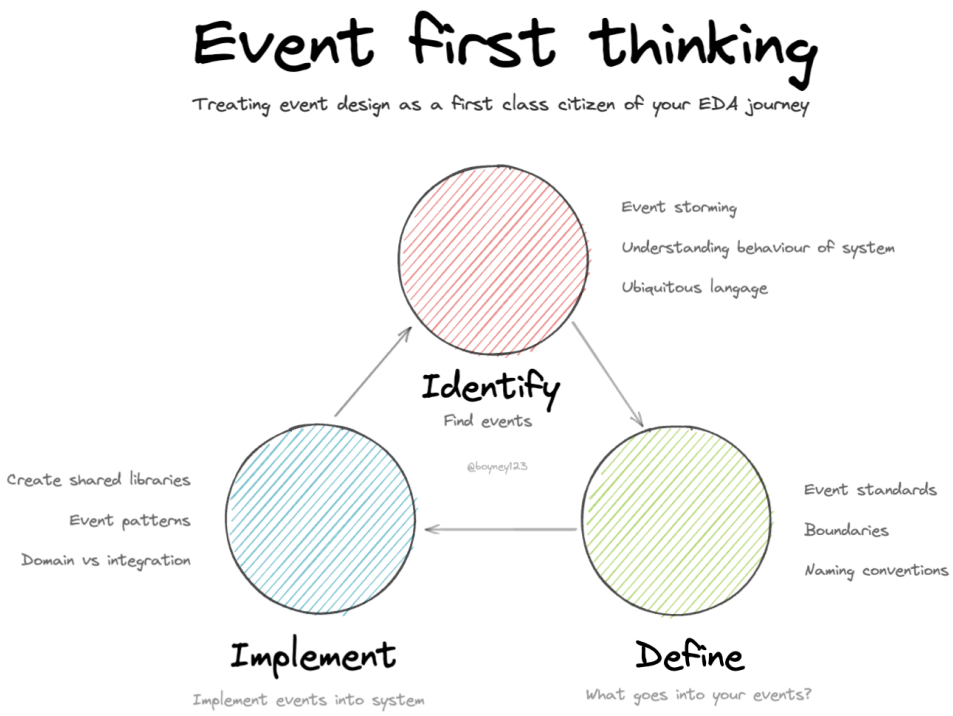


Figure 12: Event first thinking

Event identification and design within EDA applications is important, the more I researched and learnt about event design the more I believe it's a core part of an EDA application.

When we start our journey building EDA applications, we raise events from producers to downstream consumers, but what goes into our events, the structure, naming conventions, or the ability to identify our events is often overlooked.

"Event first thinking" are just some of my thoughts around all this and topics I presented last year at re:invent 2022 and EDA day in London 2022.

1. **Identify**

- Recommended using Event Storming with domain experts in your org to highlight the behaviour of your system and events that flow through.
- Find your bounded context and domains within your systems.
- Define a Ubiquitous language with your org to help communication between teams/parties.

2. Define

- Think about what you want in your events, do you want them to be notification, delta or event-carried state transfer or maybe something else?
- Think about documentation for your event, producers and consumers. How will people find the events you are publishing, what are the contracts? I created EventCatalog that might be able to help.
- Define naming conventions for your events, use these across your org and set standards, it can help.

3. Implement

- When you implement events in your producers think about shared libraries you might want to write. If you have standards, naming conventions or metadata for example, use shared libraries in your org to help. Can save time.
- Understand the design trade-offs when you choose different event types, understand them then implement them.
- Understand events "internal and external". Are your events using within the same bounded context, are they used to communicate between bounded context? Depending on what kind of events they are will determine the impact of contracts and breaking changes.

Repeat the process

I believe this process can be repeated throughout time. Business requirements change, architecture is naturally an evolution. You might want to repeat the process as time goes on.

Extra resources

- Best practices to design your events in event-driven applications - A talk I gave in 2022 around event design and trade-offs to consider.

Event-driven architecture and Conway's law

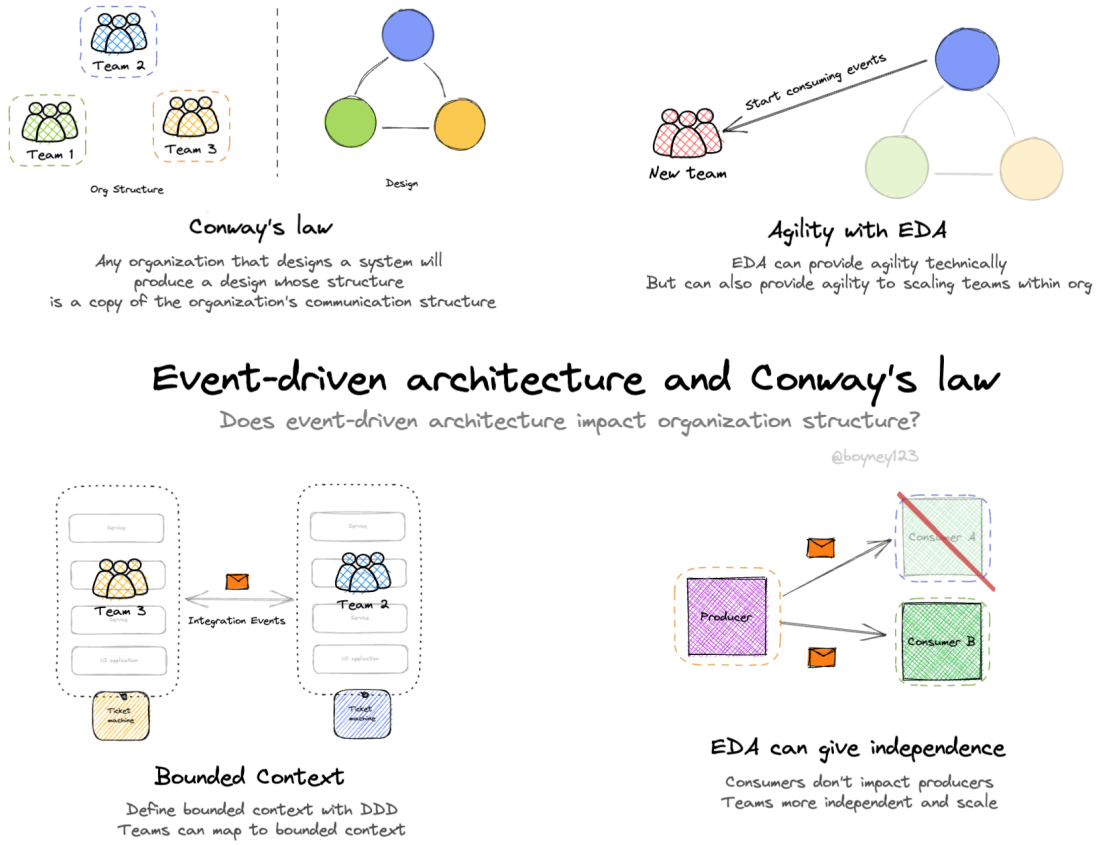


Figure 13: Event-driven architecture and Conway's law

Event-driven architectures give us the ability to create scalable, resilient and decoupled applications, coupled with domain-driven design principles we can start to use events as a form of communication between bounded contexts and teams.

Conway's law suggests that **the architecture of the system we build is a reflection of the teams that built it**, and when we couple with this domain-driven design and identify our bounded contexts and domains we start to naturally create domains and systems that exist in their own right and are decoupled from each other (sounds very similar to some of the benefits to event-driven architectures).

Agility with EDA A great benefit of event-driven architectures is the agility it can provide technical teams and also feature development. When producers raise events, consumers come and

go and choose to listen to the events (if they are interested).

EDA based architectures give organisations the ability to add more consumers to existing events, and as this catalog of events grows over time, more innovation and value can be captured.

As you add more consumers, no doubt you might also add new bounded contexts which in reflect would affect your team structure (Conway's law).

Connection between EDA, DDD and Conway's Law There is a connection between domain-driven design, event-driven architectures and Conway's law, it's important to consider that when designing and implementing your applications, you might event see a natural org structure forming around your EDA solution and vice versa.

Extra Resources

- EDA coupled with DDD - Event driven architecture and domain-driven design work well together. Here is a visual to help you understand.
- Messaged between bounded context - Event design is important between bounded context, this visual explains mapping techniques for messages before you consume them.
- EventStorming - Use EventStorming to highlight your bounded context and events, this could help identify team structure and future org structure.
- EDA is a journey... you won't get it right first time - EDA is a journey as you identify domains, events, patterns, org structures, it will take time, and that's OK.
- Scaling EDA can be hard without docs - Some thoughts around documenting your EDA applications. As you grow you will need to discover events, producers and consumers.
- Conways law with Event Architectures - Some thoughts on Conways law from Martin Fowler and a mention of domain-driven design.
- Conways law and microservices - Short post on Conways law, DDD and microservices.

Event-driven architecture coupled with Domain-driven design

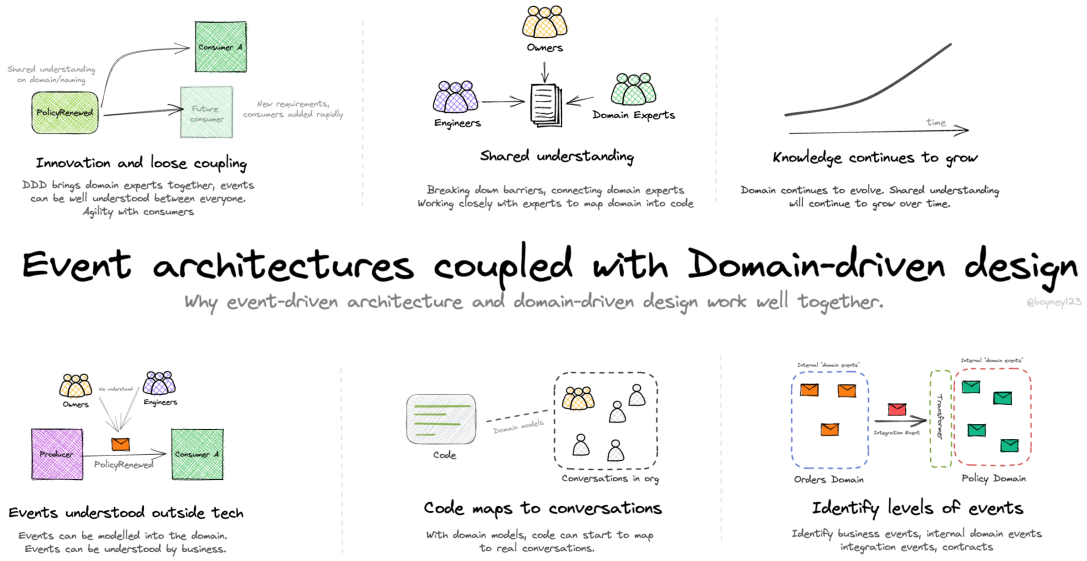


Figure 14: Event-driven architecture coupled with Domain-driven design

Innovation and loose coupling Innovation happens when we connect people together, solving issues and problems. Part of domain-driven design is connecting people, connecting domain experts with the solution that is being built and the people building it. It's only when we connect and understand our domain is we can start to innovate and build new solutions that can help. Couple this with event-driven architectures giving us a loose coupling between bounded context and services, we can reuse events and create new consumers when new requirements or innovation is required.

Shared Understanding Some of the best people I have worked with have a shared understanding of the domain they are working in, using the same terminology and modelling the domain into code, this can take time but well worth the effort. It's important to create that ubiquitous language.

Knowledge continues to grow Your domain is organic and your requirements and domain will evolve over time, once you have a map of your domain, it will continue to change. Be prepared for that.

Events understood outside tech When events are understood outside of the technical implementation new ideas can be generated. When domain experts or business owners understand domain events (events important to them/the business), they can start to come up with new features or solutions based on events that are already being dispatched vs having to write code from scratch. I have seen teams fly here.

Code maps to conversations When the domain is understood we can translate this into code, the code represents the domain, and our code can start to map to real conversations we are having. When you have well defined events these event names can be and will be brought up into conversation.

Identify levels of events When you highlight your bounded context, you will be using events inside and outside of your domain context. Internal vs External events, knowing the difference here can help. Identify, what is important for the business.

Extra Resources

- What is domain driven design? - Wiki page for DDD, start here to get a quick overview, although DDD is huge, it will take more than this page to understand.
- What is domain driven design? Continued... - A nice summary from Mathias Verraes about DDD, worth reading.
- Domain Driven Design and Event-Driven Architecture Podcast - Vaughn Vernon gives a podcast that dives into EDA and DDD. If you want to dive deeper worth a listen.
- Explicit vs Implicit events - Producers and consumers, how do they know what is in the event? Do they have a shared understanding? We are coupled but nothing stops us documenting, right?
- Eventstorming - Want to get started, trying to find events and your bounded context. Start with EventStorming.
- Document your event-driven architecture - Not really too much to DDD, but documentation can help you and your business find events and try and get that shared understanding.
- Event first thinking - Something I'm passionate about, think about events as first class citizens of your EDA design, use DDD to help model them.
- Ubiquitous Language - What is Ubiquitous Language? Visual to help.
- Messages between bounded context - How can we transform messages between contexts? Three patterns here.

EventStorming

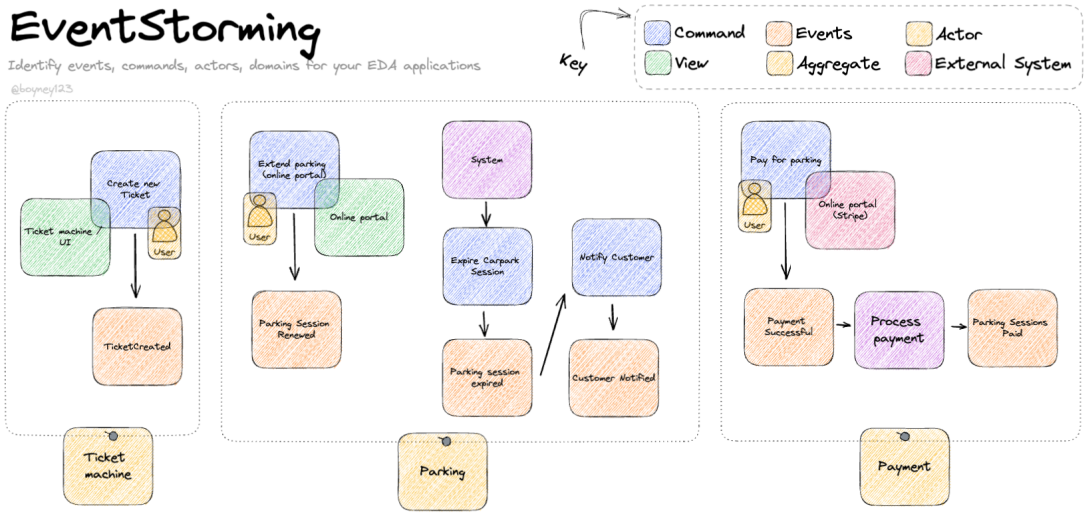


Figure 15: EventStorming

Need to figure out what events your system has? Or what commands generate events? Need to identify bounded context within your system? EventStorming can help.

EventStorming is a great method to help you identify your events, commands, aggregates and domains. EventStorming can also be used to help identify areas of duplication and complexity within your system.

It's important we understand the behaviour of the systems we try and build, event storming brings domain experts and engineers together to get a shared understanding and start to identify the behaviour of the system.

What is EventStorming? EventStorming is a workshop for collaborative exploration of business domains. You can use it on existing systems or new systems. Use EventStormting to accelerate your EDA applications.

What are the different parts / keys of EventStorming

- Orange: Events - Events written in past tense
- Blue: Commands - Command to trigger the event
- Yellow: Actors - Person who executes a command
- Green: View - View user interacts with to carry out task/command
- Pink: External System - Third party providers (e.g payment service)
- Yellow: Aggregate - Cluster of domain treated as a unit

- Purple: Business Process - Process command to generate event

Extra resources

- What is Event Storming? - Wiki link to that describes what event storming is
- EventStorming.com - Website with many resources, workshops and book about EventStorming.
- Awesome EventStorming - Huge list of resources to learn more.

Events as Data

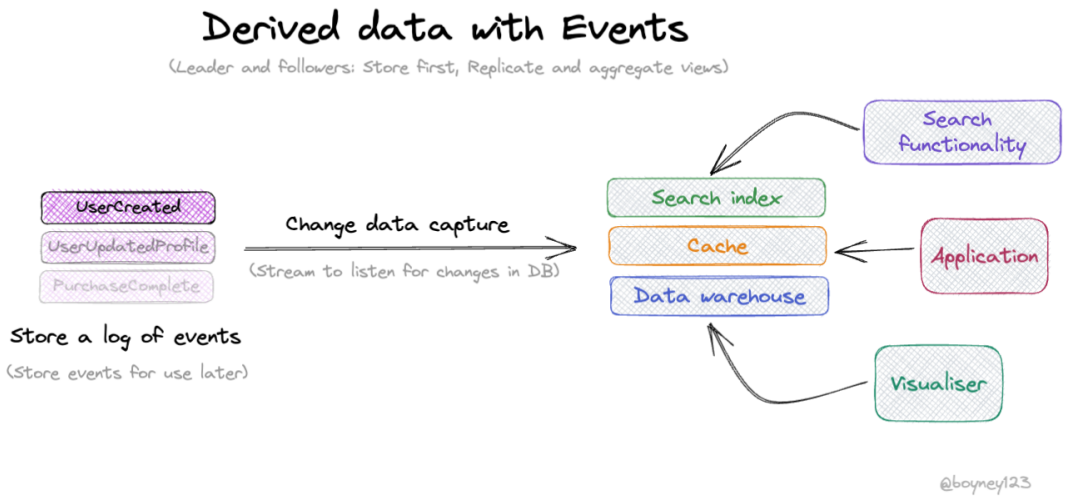


Figure 16: Events as Data

Using Event Sourcing to capture events in your system. The idea of capturing a set of events and using streams like "Change Data Capture" to process the information downstream.

Other systems have their own derived data using the events and create their own views.

Explicit vs Implicit Events

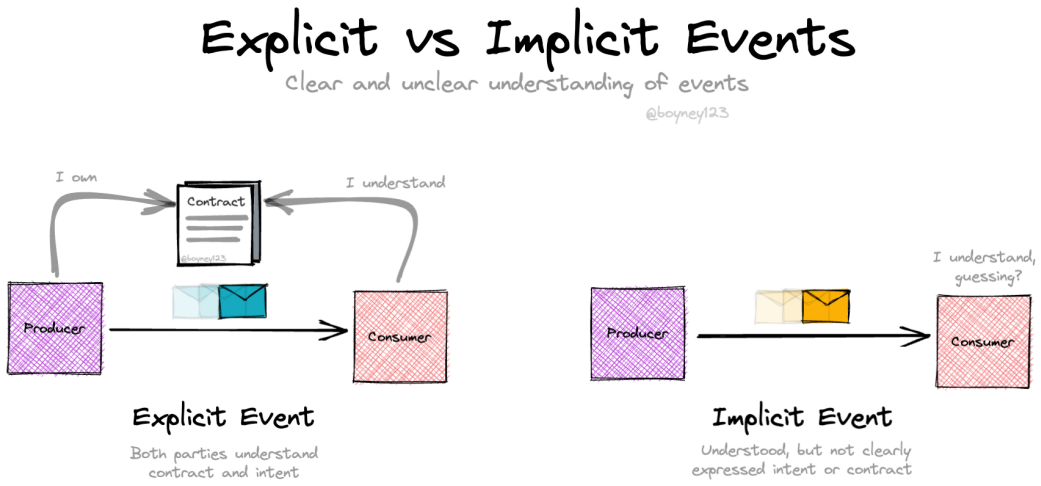


Figure 17: Explicit vs Implicit Events

When designing your events, I believe it's important to have explicit events for your event-driven-architectures. Define your events, define schemas and make sure the event itself is clear and intent can be understood. Also note producers that do not provide contracts (schemas) have increased chance of producing implicit events for downstream consumers.

Explicit Events

- Be clear on the event and it's intent
- Use clear naming conventions
- Use schemas to help define contracts
- Gives stability to both producers and consumers

Implicit Events

- Unclear event intent, try to avoid
- Unclear naming conventions
- Assumptions can be made
- Breaking changes possible without contract/schema.

Extra Resources

- EventStorming - EventStorming can help you identify your events in your system, using other stake holders it can be a natural way of defining explicit events, as events naming is often discussed.

- EDA Documentation - Documentation can help have explicit events. If consumers can discover and understand your events you are half way there.
- Event First Thinking - Events are important, designing them, thinking about them, taking your time. Treat events as first-class citizens with Event First Thinking.
- Event Types - Understand event types can help you along your event design path.
- Commands vs Events - Two different things. Be clear if your message is a command or event.
- Building Event-Driven Microservices - Thoughts generated from notes from this book.

Exposing too much information in your events

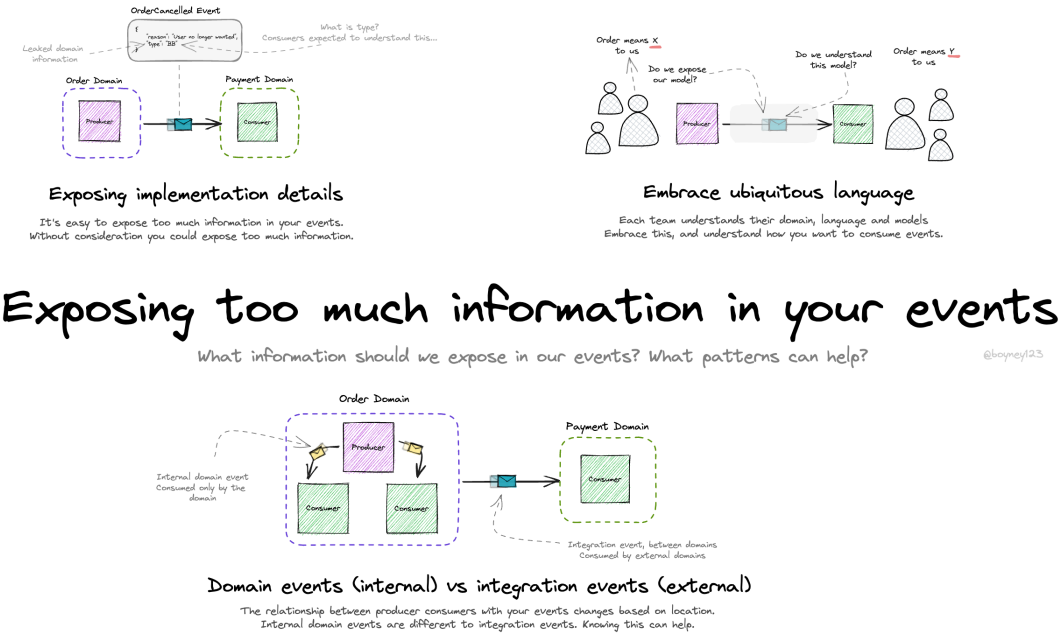


Figure 18: Exposing too much information in your events

When triggered events in your event-driven architecture, you have to be mindful of what goes into your events, and the balance between raising events with too much or little information in them. Without careful consideration you can also expose too much domain/implementation details in your events, which might lead to some interesting side effects.

Exposing implementation details

- When using events to communicate between boundaries it's easy to expose too much implementation or domain information. In the example above you can see the "type" exposed, this type is known by the order domain but downstream consumers have no clue.
- Within your own domains you will have your own domain models that tend to make to your own ubiquitous language. These models may or may not be understood by external consumers, think before you expose them.
- If consumers conform to your events with too much domain information, this domain information can bleed into other domains, and if not careful can create coupling between models.
- One way that can help is understanding bounded context mappings. Think about how you consume events, or agree contracts of events.

Embrace ubiquitous language

- Ubiquitous language is a set of vocabulary shared by a domain/product team. Language can change depending on what team or domain you talk too.
- As language changes (domain models), there is a mental mapping you may have to do between objects. We do this all the time when we communicate with other systems or teams within organisations.
- When consuming events, you may be consuming a model from another team, another language. You may want to consume this as it is or map it into your own language your code and team can understand, one way to do this is to use anti-corruption layers before consuming events.
- As organisations grow, I believe there is no getting away from teams having their own language, so embrace that and decide a strategy on how you are going to communicate between domains and teams using events.

Domain events vs integration events

- Your domain (microservice) may contain many parts, you may be using messaging or events within this domain to communicate. The events/messages are private events, they don't tend to be used by other systems, but you and your team. These have a very different relationship vs events that are consumed by other teams (integration events).
- Within your domain (or service) when you raise internal events, you have more control of the contract/breaking changes. You might be OK to put domain information or implementation details in these events, you control them and your team may be the only consumers, so they should understand the domain and information in the events, better than external consumers.
- When you use events to integrate with other domains/consumers, you need to consider your event design and the long-lived contract you may have. Exposing domain information into other domains may not be great, and you may want to consider things like a public language (open host service) that could help.

Extra Resources

- Event-driven architecture with domain driven design - There is a great overlap between event-driven architecture and domain driven design. This visual I designed can help you understand them and why it's important to know them.
- What is ubiquitous language - In this visual I created, we look and understand ubiquitous language in more detail with extra resources.
- Bounded context mapping - I like bounded context mappings, this allows us to think about patterns we use when we consume events. Should we take them as they are or map them? Or maybe agree on an open standard? Dive deeper.
- Open source bounded context mapping diagrams - Great Open Source resources here to dive deeper into context mappings, although not directly aimed at event driven architecture, they are still great and important to understand, you can map this learning into EDA.
- Event design and event first development - In 2022 I did a talk to help folks understand event design and event first development. I believe it's important to get your design right when building event-driven architectures, this talk can help you dive deeper and understand why.

Fundamentals of event-driven architecture

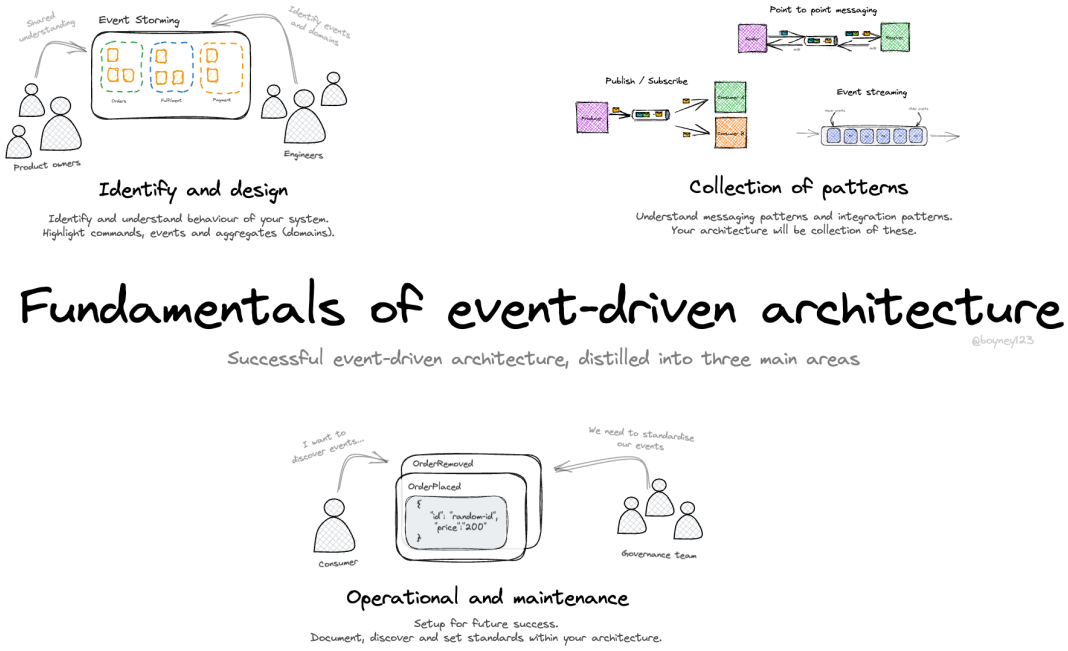


Figure 19: Fundamentals of event-driven architecture

When building event-driven architectures, how do we make sure they are successful today, tomorrow and in a few years' time?

I have distilled what I believe a successful event-driven architecture into three main areas, first is identify events and the importance in understanding he behaviour of a system. Followed by understanding messaging and integration patterns then finally spending time to understanding operational and maintenance going into the future.

Identify and design

- When you start building event-driven architectures you have two options, start to implement or stop and understand the behaviour of your system and identify your events.
- Spending time understanding your system, finding events, commands, systems and aggregates can really help you model a successful event-driven architecture.
- Event storming is a great workshop to run with your domain experts to identify events, commands and aggregates.

- Event storming brings domain experts together to discuss and negotiate how the system works and the naming of your domains (aggregates) and events. It's important to have event names that are explicit and clear.
- Once you have shared understanding of your system and identified your events, it can paint the picture you can use to start modelling your architecture and events.
- Remember event storming is not just a workshop you run at the start, come back to it in the future, keep using it to help retain the shared understanding.

Collection of patterns

- Event-driven architecture is just a collection of patterns, you may have messaging patterns and also integration patterns inside your architecture depending on what you need.
- Messaging patterns include patterns like point-to-point messaging, publish/subscribe, and event streaming. You can use these methods to pass messages/events around your architecture, and over time your architecture will likely have many of these messaging patterns.
- Integration patterns are slightly different, these are patterns you can use to help you overcome certain situations when dealing with event-driven architectures or messaging patterns. Examples of these would be claim check pattern, splitter pattern, or message translator pattern all can be found in enterprise integration patterns book.
- Understanding messaging and integration patterns can help you build successful event-driven architectures.

Operational and maintenance

- It's important to consider what your event-driven architecture will look like in 6, 12 or even 24 months. How will people find events? How will you change events? Who is producing what?
- Documenting your event-driven architecture can really help you keep maintenance under control when building your architecture. Start to think about documenting who is consuming/producing what.
- Having standards in your events can also help you scale your event-driven architecture. What information should be all events in your architecture? Maybe create a custom SDK to help you build these within your org?
- Try and think about problems you may have in the future, and spend time upfront thinking about practices you can introduce to help you mitigate away from these issues.

Extra Resources

- Event storming can help! - Event storming is a great workshop to help you identify and understand the behavior of your system. Run these workshops to help identify events, commands, systems and aggregates. Perfect way to get shared understanding and get started with event-driven architecture.
- Domain driven design and EDA - We can take so many tips from the domain driven design community when building event-driven architectures. Here is a visual to dive deeper.

- What is point-to-point messaging - Understanding messaging can help, here is a visual to help you understand what point-to-point messaging is.
- What do we mean by publish/subscribe - Notify downstream consumers that something has happened. When you build event-driven architectures no doubt you may need this pattern. This visual dives deeper.
- Discover your events - In the future people will want to know what events you have, and how you can discover them. This visual dives into event-driven architecture documentation options with some open-source projects that can help.

Good and hard parts of EDA

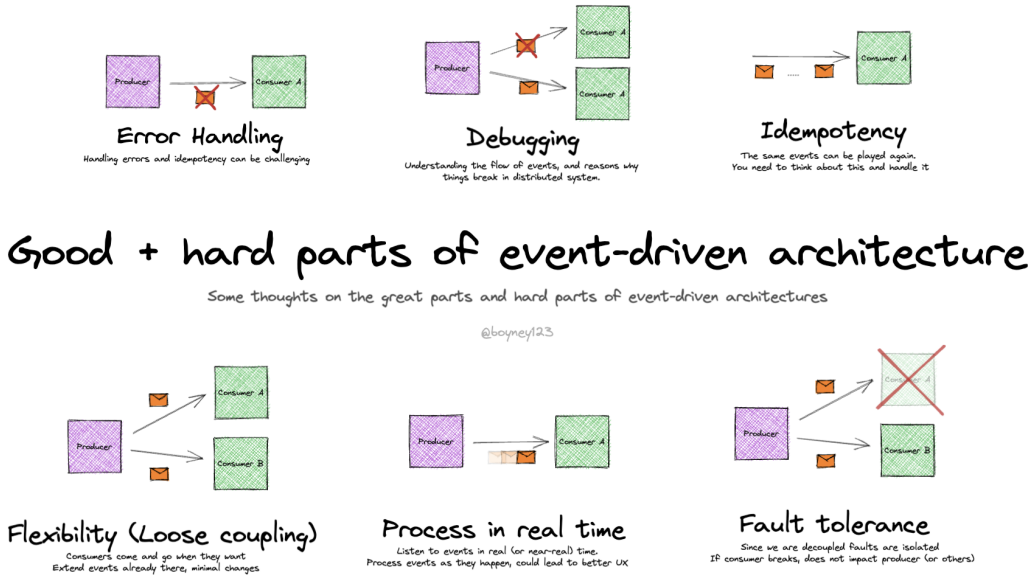


Figure 20: Good and hard parts of EDA

Good parts

- Flexibility - The ability for consumers to come and go without impacting the producer. When new business requirements occur, existing events can be listening too and consumers can be created.
- Process in real time - Some systems can allow for events to be processed in real-time or near-real time. Thinking about the user experience, could this lead to a better UX?
- Fault tolerance - Consumers are decoupled by nature, if a consumer was to break or fail to process the event, the failure is isolated to that consumer.

Hard parts *Things to think about.*

- Error Handling - When errors occur, being able to track the error and understand what is going on. Need to consider DLQ or ways to capture events before they are gone forever... if that's important to you.
- Debugging - Producers and consumers are distributed by design, so being able to trace and debug can be hard.

- Idempotency - Key to think about idempotency. If the same event was to be replayed into your consumer, what will happen? Avoid side effects, have the same outcome if event replays were to happen.

Inside event-driven architectures

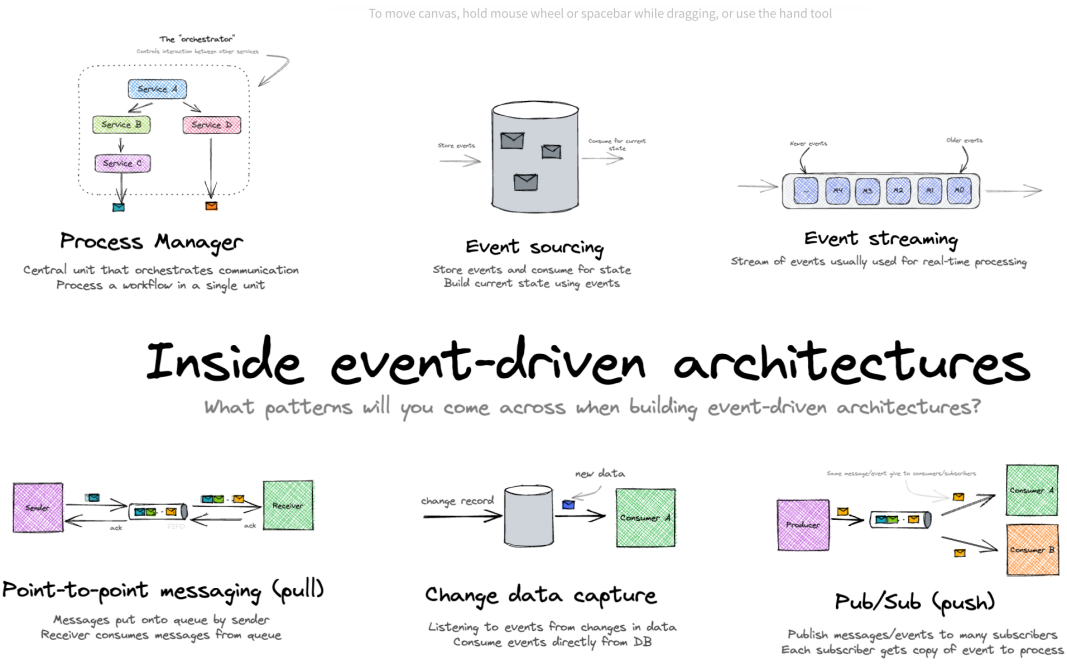


Figure 21: Inside event-driven architectures

When build event-driven architectures, you find yourself using many different patterns, not just one. When you dive into EDA applications you see a mixture of point-to-point messaging, pub/sub, choreography, orchestration, maybe some event sourcing and much more. . .

I believe using these patterns together help build a resilient, available and scalable event-driven architecture.

Process Manager

- The orchestrator that manages a workflow or process
- We have to perform business logic, this encapsulates that
- Often events are triggered from process manager to other consumers
- Example of this is AWS Step Functions

Event Sourcing

- Store events and use this information to calculate state
- Downstream projections can use this to calculate their own view of world
- Change data capture popular to listen to changes
- Audit is great here, as you can see everything that is happening.

- Example is storing events into NoSQL DB like Amazon DynamoDB

Event Streaming

- Often used to process information in real time
- Examples seen with user interactions on some form of interface (e.g. clicks)
- Messages are put onto the stream, consumers pick where they want to listen
- Offsets are used by consumers to read messages from the stream.
- Example of this is Amazon Kinesis

Point-to-point messaging

- Send messages to a channel for downstream consumers to process
- Multiple consumers can pick up messages from queue for concurrent processing
- Highly scalable pattern
- Example of this is Amazon SQS

Change data capture

- React to changes when they are made against your data
- Listen for new, delete or updates
- Attach consumers to changes to process information
- Example of a DB that supports this is Amazon DynamoDB

Pub/Sub - Fire notifications out to downstream consumers - Fan out events - Consumers get own copy of event - Create for decoupling applications and scaling teams - Example of this is Amazon EventBridge

Extra resources

- Point-to-point messaging - What is point-to-point messaging? When should you use it? Visual I created to help you
- Choreography vs orchestration - What's the differnce? Using process managers to orchestrate workflows or using events to communicate between services, maybe a world of both? More than likekly...
- Pub/Sub - What is Pub/Sub? When do events get pushed to consumers? Why use this pattern? Visual here to help
- Event-driven architecture with domain-driven design - How does domain-driven design help us build event-driven architectures? Take a look to understand why.

Internal vs External Events

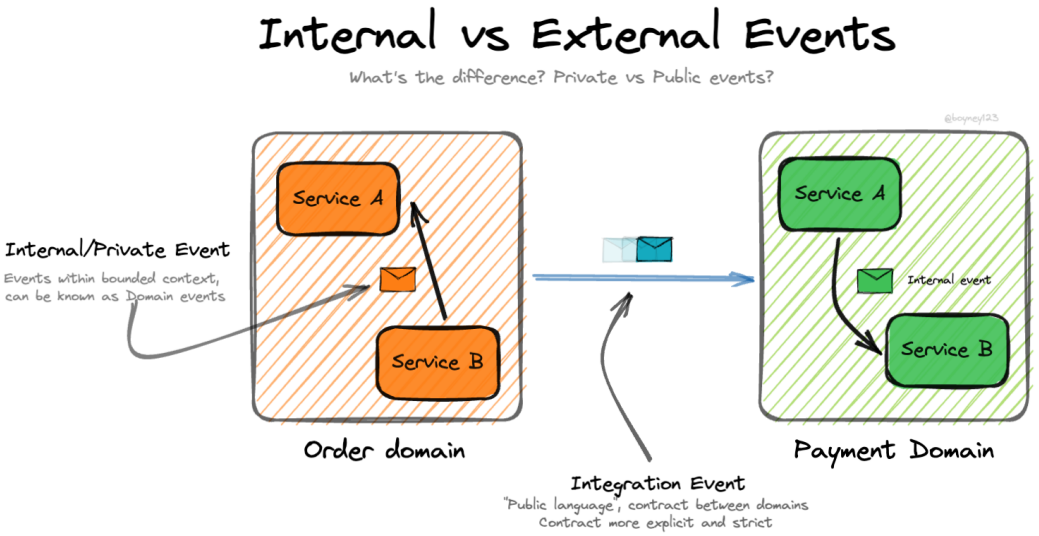


Figure 22: Internal vs External Events

When you build event-driven applications you can use events to communicate between services and boundaries. Many people use EventStorming to highlight events and business domains.

Within a bounded context you can have many different services and communicate between these services using events, sometimes these are referred to as **"private"**, **"internal"** or **"domain"** events (depending on what you read...). These events belong within the bounded context, they can be exposed to implementation details and raise events assuming that downstream consumers understand the domain language used in the boundary and implementation details, they are "private" and not meant for "public" consumption.

Using events to communicate between between bounded contexts (remember this can be within in your organization or outside your organization) can be referred to as "public" or "integration" events. Event contracts are important here, and ideally you do not want to expose private or implementation details of your domain in these. Consider a public language to communicate between systems (Defining a ubiquitous Language can help here).

Private/Internal Events

- Can expose internal implementation details
- Use a language that the domain understands, external domains may not understand this
- Contract is important, but depending on how "close" the services are within boundary, could be relaxed?

Public/Integration Events

- Should not really expose implementation details of the domain
- Events use a language that is shared between the business or boundaries, no assumptions made
- Contract is extremely important. Outside your domain you have less knowledge of who is consuming your events, don't break them.

Extra resources

- Learning Domain Driven Design - Some notes taken from the book "Learning Domain Driven Design" by Vladik Khononov.

Journey to event-driven architecture

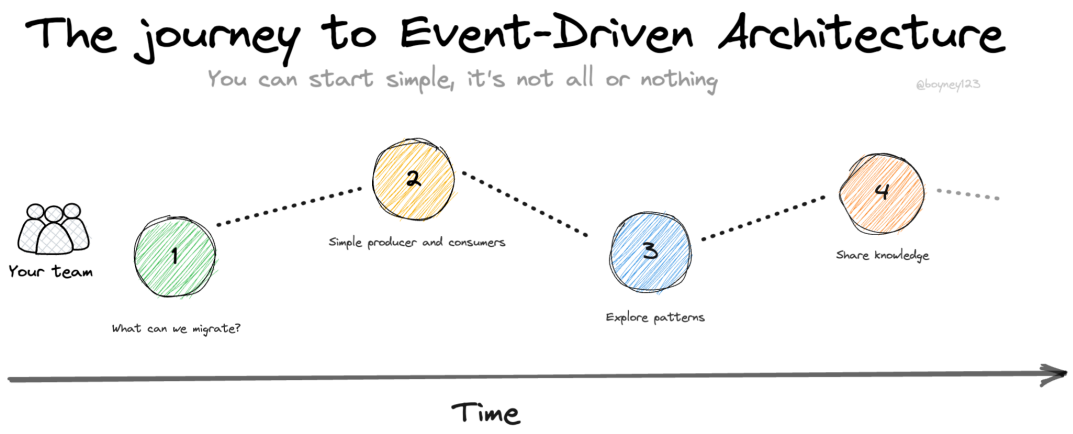


Figure 23: Journey to event-driven architecture

Software changes all the time. Requirements change, technology changes and patterns change. Using event-driven architectures can be great, as they allow you to be agile and adapt to change fast, but the road to implementing event-driven architecture does not happen overnight.

Implementing an event-driven architectures is a journey, a technical journey but also a journey for your organisation. There are many benefits to building event-driven architectures but the implementation itself is a continous effort (like all software we write!).

If you have legacy code and you want to move to an EDA application, you can use migration strategies to slowly migrate services into an EDA landscape (if it makes sense)! If you are looking to migrate I recommend using EventStorming to identify the behaviour of the system and start raising some basic events and consumers. Grow the producers and consumers over time and start to decouple your applications. Find the natural bounded context in your business domain and start to communicate with events.

If you want to build event-driven applications or already do, I believe it's a journey and it will be a continuous journey, paired with ever changing business requirements EDA can be a great option to remain agile and adapt to change.

Start small, and grow your implementation over time.

Extra resources

- EventStorming Visual - Visual to help you learn about EventStorming.
- EDA Guide - Short guide to help you get started with event driven architectures.

Local cache copy vs requesting data

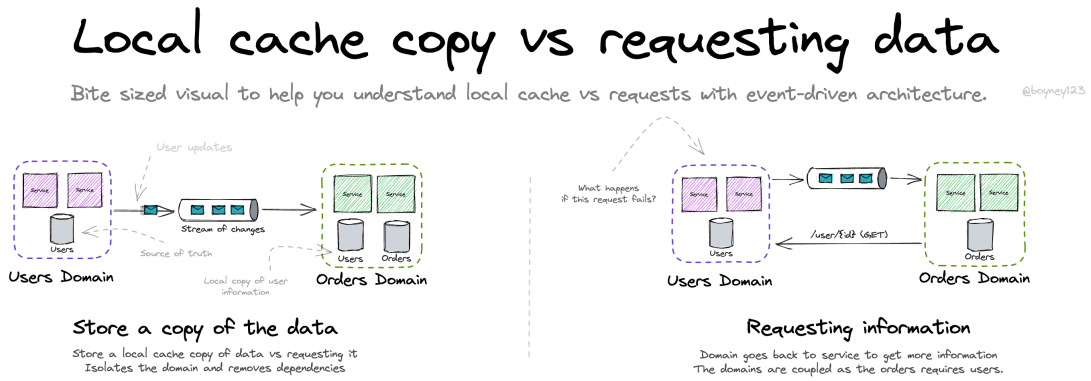


Figure 24: Local cache copy vs requesting data

When using messages/events to communicate between boundaries/services, downstream consumers may want to request more information, this is common when events do not contain all the information required for downstream consumers (e.g notification events).

There are a few patterns engineers follow to solve this problem, more commonly they may go back to the producing service to request more information, or they change the payloads of the events (event-carried state transfer) and let other boundaries keep a local cache copy of the information, removing the need to go back to the producing service to get information.

Storing a copy of the data

- When consumers read events, they may require more information (depending what's in the event). Rather than requesting this through an API, the contract of the event may change (larger events) and a local copy of this data is stored.
- When the consuming service needs information outside it's boundary it can look into it's local cache copy and get what it needs without going outside (e.g back to the producer or API).
- Let's look at the visual example. The **order domain** has all the information it needs about the user (from the **user domain**). When changes occur about the user this information is broadcasted (e.g change data capture) as an event and the order domain consumes this and stores a copy of the information.
- This means we are not coupled to the **users domain** which can improve our availability, but the trade-off here is the data within the orders domain can be inconsistent/stale and eventually consistent, something to consider if you using this pattern.

Requesting information

- When consuming an event that does not have all the information required (e.g notification events), downstream consumers may request information outside its boundaries (e.g. API back to get user information).
- Having consumers make requests outside it's boundary can create a coupling between that service and the service providing the information.
- In the visual we see the **order domain** requesting more information about the user, they do this using a `GET` request back to the **user domain**. This creates a coupling between the services/boundaries.
- When **orders domain** requests this information, it can create a back pressure onto the **user's domain**, if you have high thoughput this can impact your availability.
- This pattern allows the order domain to get relevant and up to date information about the user, which improves the consistency of the data, but at a cost of availability.

Extra Resources

- Local cache with Ian Cooper - Ian Cooper from Just Eat gives us an example of using event-carried state transfer to share information between boundaries and keep a local cache state of the data.
- Shared data with Randy Shoup - Randy Shoup gives us some patterns about sharing data with messaging/events. Sync vs Async and much more, great talk to dive deeper.
- Local cache with Derek Comartin - Great collection of resources here to dive deeper with Derek Comartin, if you want to learn more with code examples check this out.
- What is CAP theorem - In this visual we talk about consistency and availability trade offs, this comes back to the CAP theorem, worth reading and understanding the trade-offs this theory represents us with.
- Event first thinking - This is a talk I gave back in 2022, I speak about event design but also the trade-offs between event types which is relevant to this visual.
- Understanding eventual consistency - When dealing with copies of data, you may want to be aware of eventual consistency, this visual helps you dive deeper.

Message Delivery

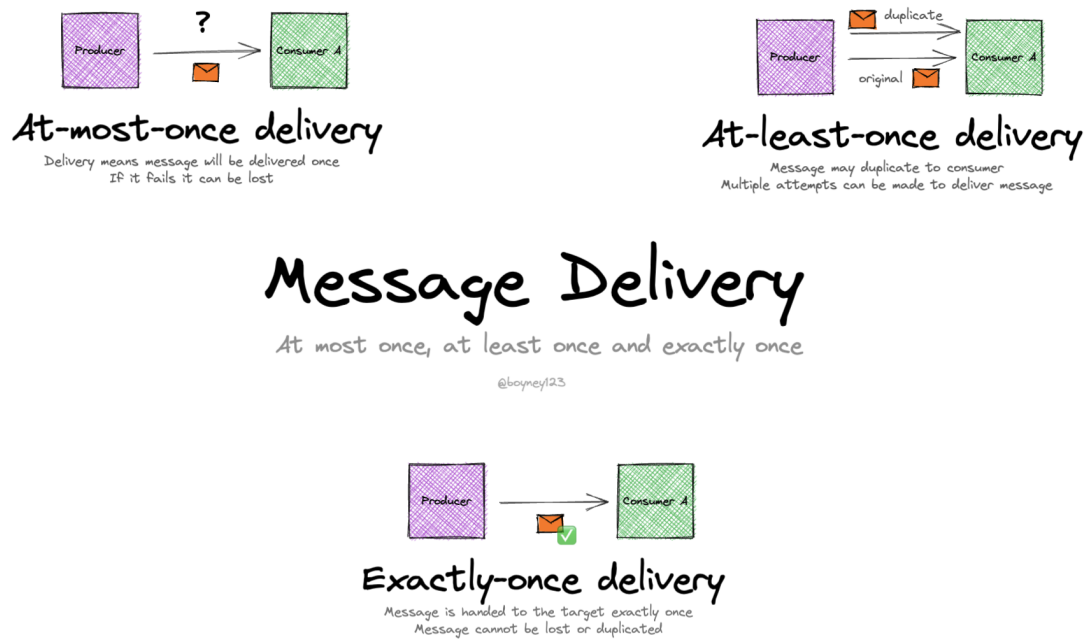


Figure 25: Message Delivery

Different systems will provide different messaging solutions, understanding these can help you understand how your messages will be given to downstream services.

At-most-once delivery

- Delivery means message will be delivered once
- If it fails it can be lost

At-least-once delivery

- Message may duplicate to consumer.
- Multiple attempts can be made to deliver message.
- Important to have idempotent consumers
- Multiple attempts can be made to deliver the message to the target until one succeeds. This means messages can be duplicated but not lost.

Exactly-once delivery

- Message is given to the target exactly once

- Message cannot be lost of duplicated

Extra resources

- At-least-once delivery - Short blog post to help.
- Exactly-once delivery - Short blog post to help.

Message Queues vs Event Brokers

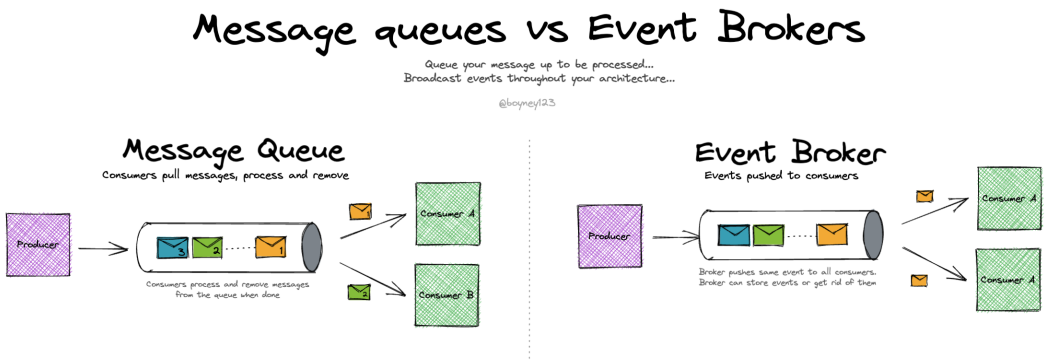


Figure 26: Message Queues vs Event Brokers

Message Queue Messages are put onto a queue and a consumer consumes the message and processes them. Messages are acknowledged as consumed and deleted afterwards. Messages are split between consumers which makes it hard to communicate system with events.

Example of this would be Amazon SQS. Publish messages to the queue and then listen to them, process them and they are removed from the queue.

Event Broker Event brokers are a push system, they push these events downstream to consumers. Example of this would be Amazon EventBridge.

Extra Resources

- Building Event Driven Microservices - Notes mainly from this book by Adam Bellemare

Message translator pattern

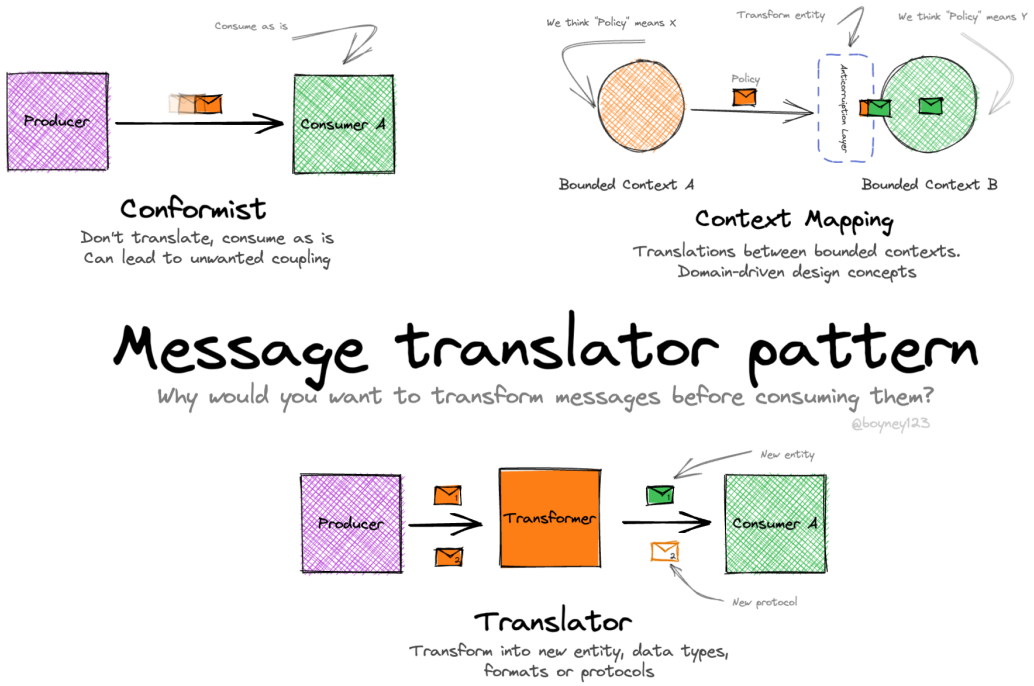


Figure 27: Message translator pattern

Use the message translator pattern to transform data format into a another one.

Examples of this might be transforming the message into a new entity (e.g. Stripe Payment into your own internal model), change data types (e.g. concatenate first name and last name into a new field) or new protocol (transform JSON into XML).

When building event-driven applications you may think you are decoupled by design, but the **message/event contract itself can couple you**...

Things to ask yourself when consuming events:

- Should my consumer conform to the event?
- What are the risks if we consume as is (this might be OK!?)
- Should we transform the message/event?
- Does this event/message conform to our understanding (ubiquitous language of our domain)

If you just think about these questions when consuming events, you are already half way there.

How does domain-driven design fit into this? When you define your bounded contexts (aggregates of services for example), you might be using messages/events to communicate with each other (integration events). There are different patterns to consider when consuming events rather than just conforming to the event payload/structure, it's worth checking them out.

Summary

- Use translator to transform messages
- Transforming messages can help you keep your producing and consuming applications decoupled
- When both parties conform to the structure of the message, you may run into coupling, this might be OK, but just be aware.
- Having transformations on the edge of your bounded context can help isolate the need for change when changes occur in your schemas/messages/payloads.

Extra resources

- Message Translator Integration pattern - Enterprise integration pattern for message translator, if you want to know more head here.
- Transform messages between bounded context - Conform, Transform or open-host service when listening and consuming events. Patterns worth checking out if you are interested in the transformation pattern.
- Content enricher pattern - If you are after more patterns, check out the enrichment pattern. You can enrich your messages/events before sending them downstream to consumers
- Claim check pattern - Simplify your events by storing data first and a reference back to the event downstream, save on payload size.

Messages between bounded context

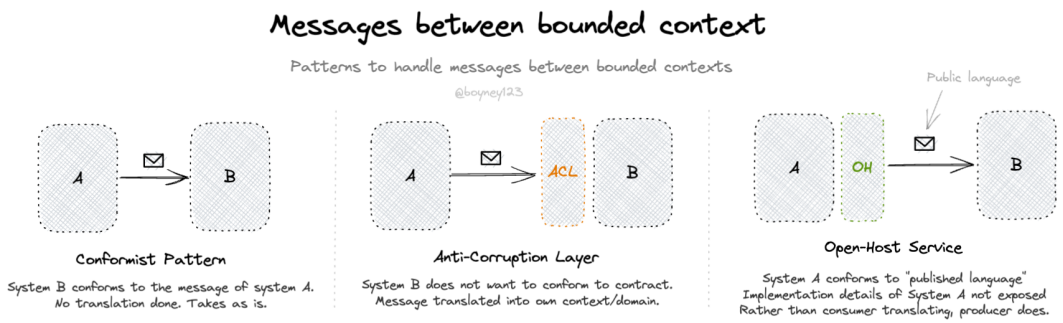


Figure 28: Messages between bounded context

When sending data between bounded context you have a few options to handle the data/contracts.

Conformist Pattern

- System A sends data to System B. System B does no translation of the data before using it within it's bounded context.
- System B conforms to the data/contract.

Anti-Corruption Layer

- System B does not want to conform to the contract of System A.
- System B translates the data into a domain model it can understand.

Open-Host Service

- System A sends data to System B but translates it before it is sent.
- Public language is used between systems.
- Integration details of System A is still locked away, but public inteface/message exposed.

Extra Resources

- Learning Domain Driven Design - Notes taken from the book "Learning Domain Driven Design" by Vladik Khononov.

Point-to-point messaging

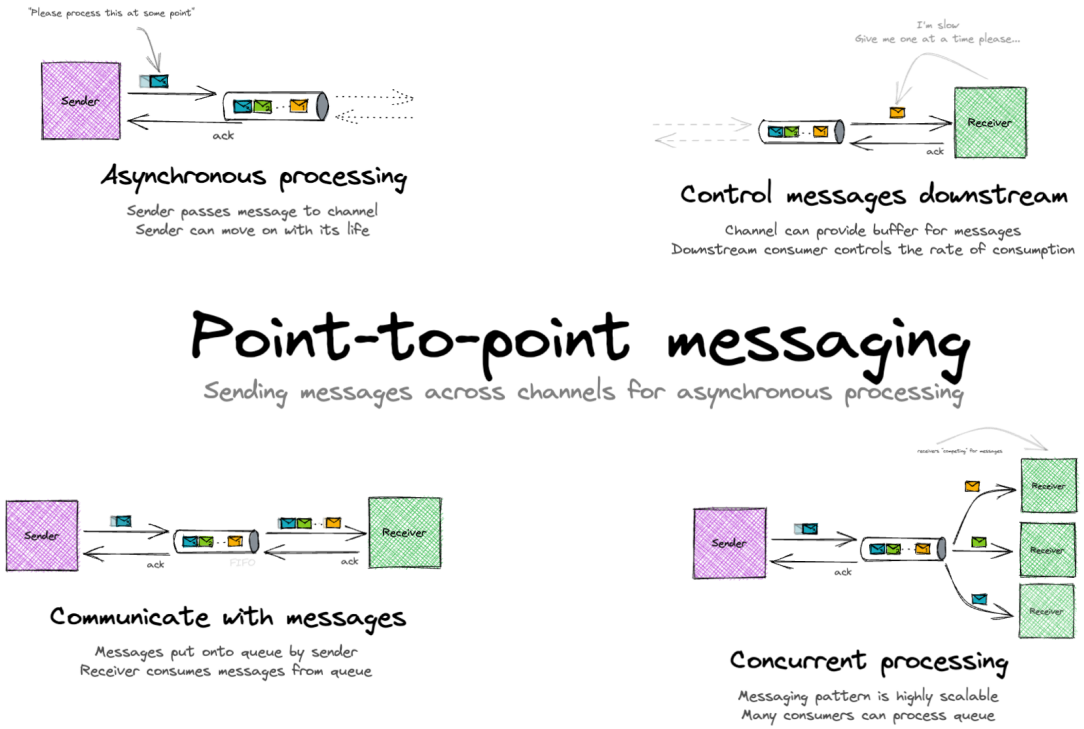


Figure 29: Point-to-point messaging

Point-to-point channels are used for handling messages between a sender and receiver. The sender puts messages onto the channel and the receiver consumes these messages from the queue (at the rate they want).

Great for scalability Point-to-point channels can have many concurrent receivers, this is what makes them a powerful for scaling, you can scale your processing of messages from the queue. Having many consumers can also be known as "competing consumers" as described by the enterprise integration patterns book.

Typically, the channel controls which consumer has which message as consumers pull messages from the queue.

Reducing pressure from consumers You can also see point-to-point messaging being used to release pressure from receivers. Receivers can control the rate of consumption; this is great if you have an API that cannot handle the throughput of messages.

Just one of many patterns Your event-driven architecture will consist of many different patterns and point-to-point messaging is just one of them. If you want to fan out messages to consumers you need to look at the pub/sub pattern.

Extra resources

- Understanding Pub/Sub - Visual and resources to help you understand pub/sub pattern.
- Competing consumers - When using point-to-point messaging you can have many receivers, this is known as competing consumers.
- EDA Guide - In our EDA guide we also have many more patterns and information to help you dive deeper into EDA.
- Eventual Consistency - When you have async message processing, the task/process downstream can take time, you need to know how eventual consistency can effect your architecture/application.

Producer and consumer responsibilities

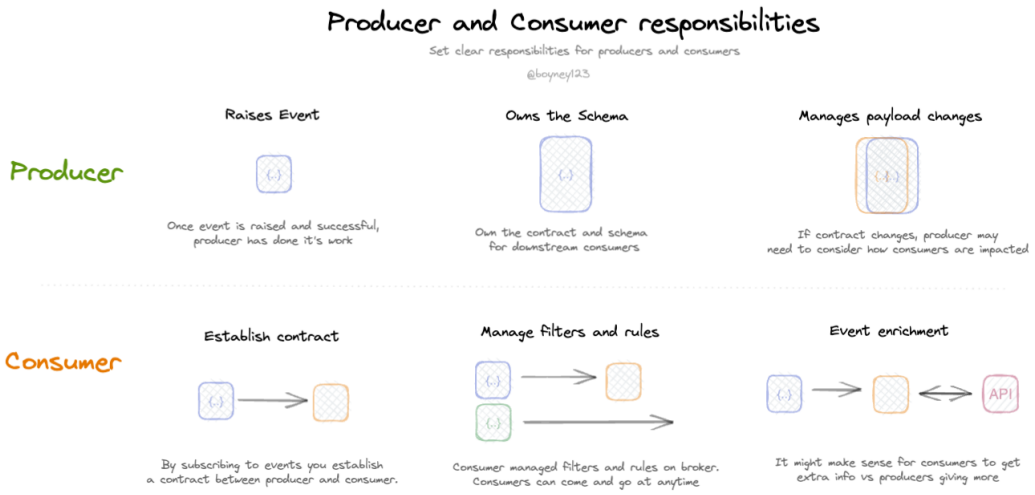


Figure 30: Producer and consumer responsibilities

When building event-driven applications it's important to know the responsibility of the consumer and producer. This diagram represents my thoughts on it, but I think from design to design it may differ.

Use this diagram as a base, but you may want to adapt it based on your architecture.

Publishing events, without any consumers...

Figure 31: Publishing events, without any consumers...

Should we publish events even though we don't have any consumers? Some say no, but others think there is value. Let's take a look.

Future extensibility

- Event-driven architecture allows us to be decoupled and have an architecture we can extend when consuming new events. If we want new events, we go back and add them, what if the events are already there? Just not consumed yet?
- Having events without consumers is something to get your head around, but it would mean you can add consumers in the future with little or no effort.
- If you had a catalog of these events, consumers could come and go as you see fit, that's the whole point isn't it?

Write the code, publish the event

- You are in the code anyway, writing the feature, why not emit the event when a business process has been done? Example would be sending an email, you write the code to send the email, then why not raise the event too.
- Publishing events without consumers or any "need" might seem counter intuitive though, this is code and events we have to maintain, so does that come at a cost we have to consider?

- Some brokers may charge for publishing events, so that is also something to consider.

Interest over time

- Today your consumers may not be interested in your events, in the future they might... if the events are already there to be consumed, the effort of integration could be lower?
- Maybe identify which events you want to publish "without consumers", if they are internal private to that domain, the maybe that doesn't make much sense? But if they are business domain events, it could?

Summary Personally, I'm not sure where I sit on this, I can see the value but also any code we write or events we publish we have to maintain. But this is something that I never really considered and come across, so it could be an interesting pattern to explore.

Maybe identify core business events, and raise them, there will be a higher chance of consumption vs private or technical events you may raise.

Extra Resources

- Fundamentals of Software Architecture - Idea came from this book, talking about Event broker topology. Great book to dive deeper.
- Document your events - If you are going to publish future events, it's worth documenting them for consumers.
- Event Storming - Publishing all events might not be correct, but maybe some core business events might make sense? Use your judgement.

Queues vs Streams vs Pub/Sub

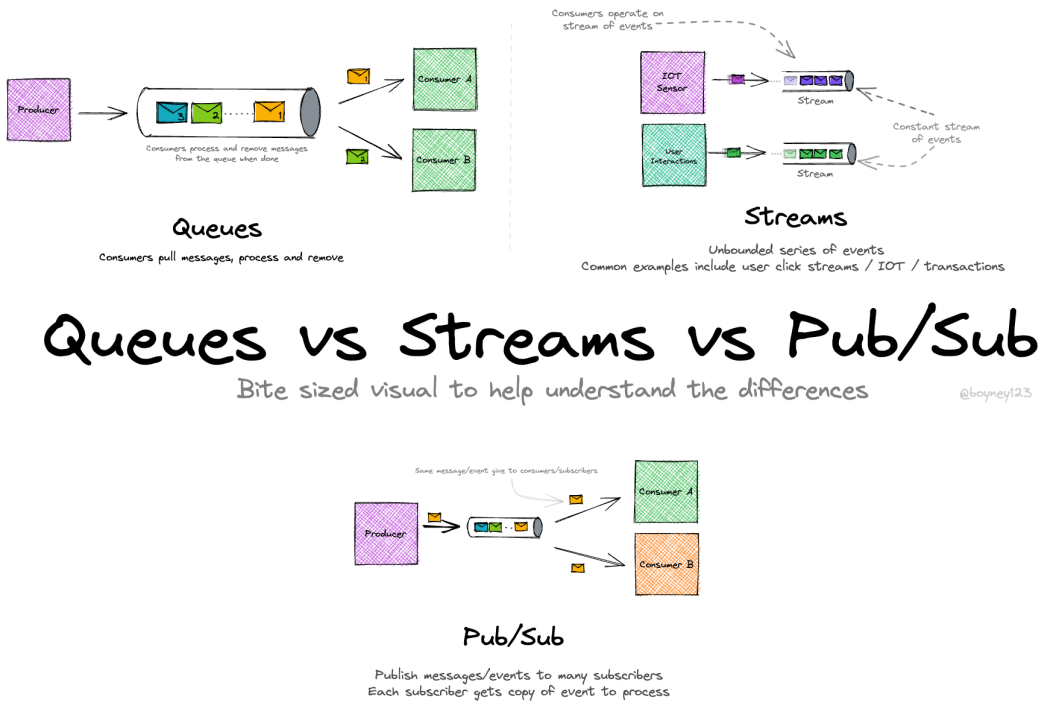


Figure 32: Queues vs Streams vs Pub/Sub

When working with event-driven architectures it's important to know the difference between **queues**, **streams** and **pub/sub**. At a glance they may look similar but they are completely different.

Queues

- Messages are put onto a queue and consumers consume the message to process them.
- Messages are acknowledged as they are consumed and deleted after they a processed.
- Messages can be consumed by many consumers giving you the ability to process messages in parallel also known as Competing Consumers (as seen in the Enterprise Integration Patterns).
- An real-world example of this would be queuing at the shops. You stand in one big queue (message queue) with one cashier (consumer), that cashier is processing each shopper (message). Shops open up more cashiers (consumers) to help with the customers (messages). Similar thought process with channels, messages and queues.
- Explore the "Point-to-point messaging" visual to dive into messaging patterns.

Streams

- Event streams involve processing data as it happens. Event streams are a continuous flow of data that can be collected and processed in (near) real time.
- Think of streams as a series of unbounded events (events that never end).
- Typically, messages in streams are ordered (based on partition/topic), depending on solutions used.
- Consumers can read events in the stream from a particular point in that topic/time.
- Read the "Understanding Stream and Discrete Events" or "Understanding Event Streaming" visual to dive deeper.

Pub/Sub (Publish/Subscribe)

- Publish events to many downstream consumers.
- Consumers get their own copy of the message to process (unlike queues, where messages are pulled from the queue).
- Consumers (subscribers) come and go, producers (publishers) produce events often without knowing downstream consumers.
- Read the "Understanding Publish & Subscribe" messaging visual to learn more.

Extra Resources

- Enterprise Integration Patterns - Fantastic resource to dive deeper into integration patterns, a must read if you want to learn more.
- Enterprise Integration Patterns 2 by Gregor Hohpe - Watch this video to dive deeper into the making of a pattern language. Dive deep into messaging patterns and learn more.
- At-most-once, At-least-once and Exactly-one delivery, what does it all mean? - Visual I created to help you understand message delivery and what it all means. Good to know to help you pick the right technology for your use case.
- Understanding Idempotency - Here is another visual that can help, understanding idempotency. If you are building message-based applications it's worth understanding this, this can help you plan and scale your event-driven architectures so you don't get unwanted side effects of replaying events/messages.
- What happens what messages/events fail? - How can you handle failures? Here is a visual to help you dive deeper and be prepared.

Reducing team cognitive load with event-driven architectures

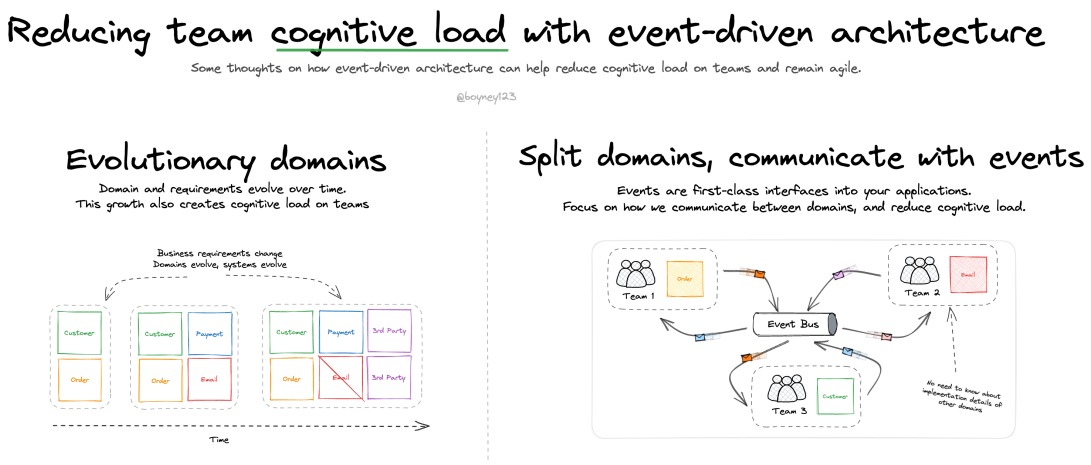


Figure 33: Reducing team cognitive load with event-driven architectures

It's inevitable that software evolves over time, requirements change, domains within businesses change.

At the start of a new project, it seems relatively simple for us to get a holistic view of the whole system/architecture.

As time goes on services evolve, business requirements change and (hopefully) organisations grow and scale. This means the cognitive load to understand the architecture and business domains increases and things can become harder to scale, work with and adapt.

Event-driven architectures can provide the ability to respond to changes, design architectures that support evolutionary changes within organisations and provide teams the ability to scale whilst **reducing the cognitive load** required to understand the architecture and business domains within it.

Evolutionary domains

- Software changes all the time. Businesses get new requirements, requirements change, new services are created or services are depercated. **The landscape is constantly evolving**.
- Teams at the start of the project may be able to fully understand the "whole picture", the business domain and every single service they build, but over time as teams scale it can be challenging to rapidly scale with everybody needing to know everything.
- With event-driven architectures messages/events can be used to communicate between boundaries, this enables teams/domains within organizations to focus on a particular business

problem (or collection of problems) and use messages/events to communicate with other boundaries/systems.

- Having teams focused within domains allows them to specialise within that domain.

Split domains, communicate with events

- Many businesses want to scale, and want their software architecture to enable agility.
- Splitting teams into domains/services is a common pattern organization use to able growth.
- Teams within the domains are specialists of that domain. They understand the needs/requirements of the business within that domain.
- Teams can use messages/events to communicate between boundaries. This allows them to design a contract that can be used and notify others.
- This pattern reduces the cognitive load that teams need when developing solutions within their domain, but it is **still required for someone to have the bigger picture**.
- One common mistake when building event-driven architectures is losing the "bigger picture". For example, standards of events, documentation of the system, how to handle retries, idempotency etc.
- Having engineers/architects that understand the whole domain is super important, and can help guide engineers within these teams.

Extra Resources

- Large-Scale Architecture: The Unreasonable Effectiveness of Simplicity - This visual was inspired by Randy Shoup. This is a great talk about large-scale architectures, talking about async, event-driven and patterns to help. This reminded me of the importance of reducing cognitive load when scaling teams.
- The fundamentals of event-driven architecture - Another visual I made about the fundamentals of EDA. Reducing cognitive load is just part of the benefits you can get when using EDA, this visuals dives deeper into some of the fundamentals I believe we need to understand before building EDA applications. Hopefully it can help you.
- Publishing events without consumers - Think of events as an interface into your domain, you don't have to only publish events when consumers ask for them, think about your domain and publish events even without consumers.
- Bounded context with event-driven architecture - Directly from domain driven design, the bounded context. Super important to understand if you want to create domains/boundaries around your services and uses events/messages to communicate.
- Use event storming to help identify your domains - If you are trying to find your domains or want to dive deeper with your teams, check out this visual to help. An overview of Event Storming and resources to help you.

Schema Management

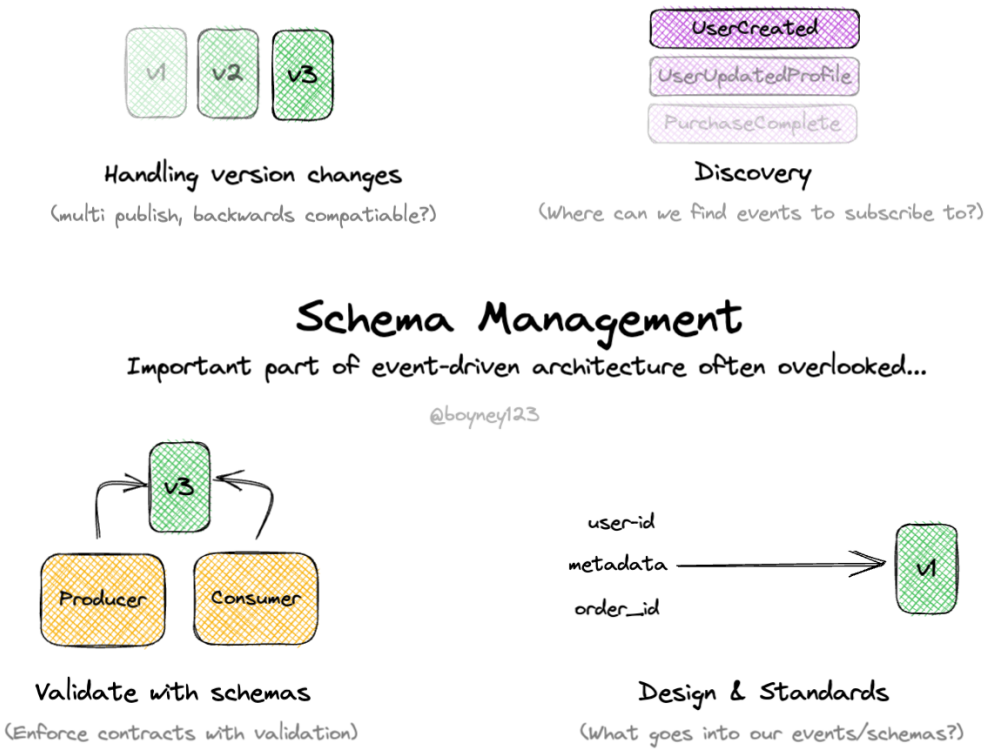


Figure 34: Schema Management

As EDA applciations grow developers often find schemas to be a more important part of their EDA application.

1. What events can I listen to?
2. How are we going to manage change in our events?
3. What do the events look like?
4. What goes into our events?

Extra Resources

- AsyncAPI - AsyncAPI specification, the industry standard for defining asynchronous APIs.
- CloudEvents - A specification for describing event data in a common way
- Event Payload Standards - Blog post about Amazon EventBridge payload standards, lessons can be applied anywhere.

Splitter Pattern

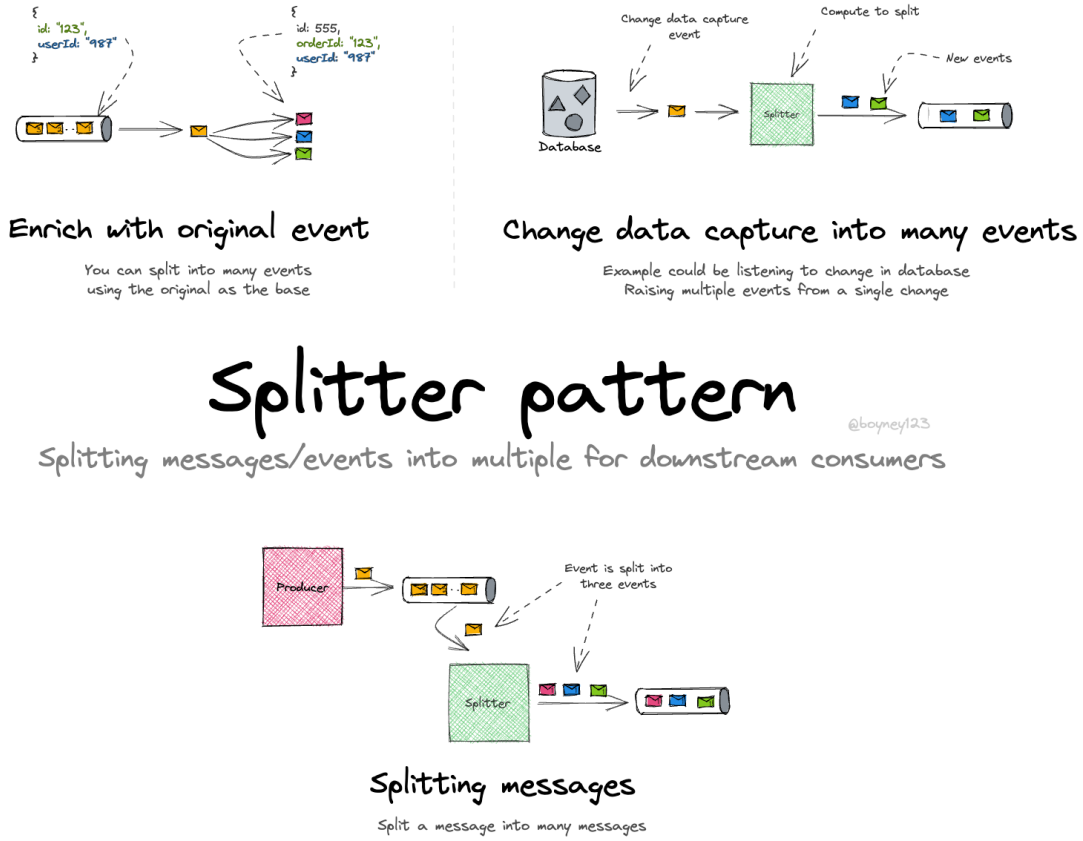


Figure 35: Splitter Pattern

The Splitter Pattern from Enterprise integration patterns, takes an event/message and splits it into many for downstream consumers.

Splitting Messages

- If you have a large message/event you can use a splitter to split it into many messages/events for downstream consumers.
- Using a queue an example could be the splitter takes a message from a queue, splits it and puts it back onto a new queue/channel.
- This pattern can be helpful if you want to process large messages or events, or have a business use-case where it might make sense to split. Example could be taking an order and splitting into it's sections (as seen here).

Enrich with original event

- When you split your event, you may want to duplicate the information into the child events, depending on your data strategy. If you duplicate then downstream consumers may have the information they need to process, or the can go back to producer/API to get information they need.
- Splitter consumes original event, uses information to build payload for child events.

Change data capture into many events

- Databases that support change data capture events allow us to react to events when data is changed in databases.
- An example use-case could be listening for database changes (using change data capture) and transforming these events into multiple events downstream.
- An example of this could be using DynamoDB stream, into EventBridge Pipes to create many events downstream. Example here.

Extra Resources

- Splitter pattern from enterprise integration patterns - This pattern is from the enterprise integration pattern book, if you want to learn more, recommended checking this out.
- Aggregator pattern - The opposite to the splitter, this takes events in, aggregates them into one message/event downstream.
- Example using DynamoDB with EventBridge Pipes - Some code examples to show you how you can do this with AWS services, all open source.

Sync vs Async Communication

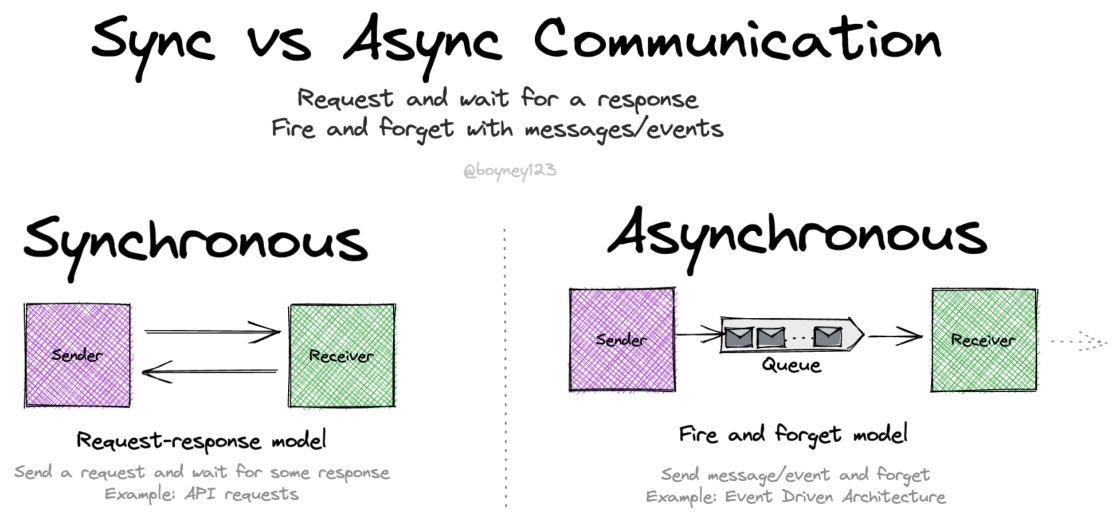


Figure 36: Sync vs Async Communication

When we design our architecture and build our services it can be useful to know the different types of communication patterns. Although pretty simple, I think it's important to know the difference between sync and async.

Sync

- Normally seen as the "request/response" pattern. Example would be taking a phone call, you need both parties there.
- An example of this could be a command, many API calls want something to happen.
- Fails fast, simple and low latency
- What happens when many requests come in? Need to scale the service, could you use Async pattern instead? Something to consider.

Async

- With EDA a producer can fire an event and forget it and allow downstream consumers to process it (if they want...)
- With messages, a message could be added to queue and downstream services control the speed of injestion and process async.
- Async provides a loose coupling between services/systems.
- Receiver can control the rate of consumption of events/messages
- Example of this would be Amazon SQS.

Extra resources

- AWS: Re:invent 2022 - Building next-gen applications with event-driven architectures - Video on building EDA applications and speaker talks through communication patterns.

Things to consider when building EDA architectures

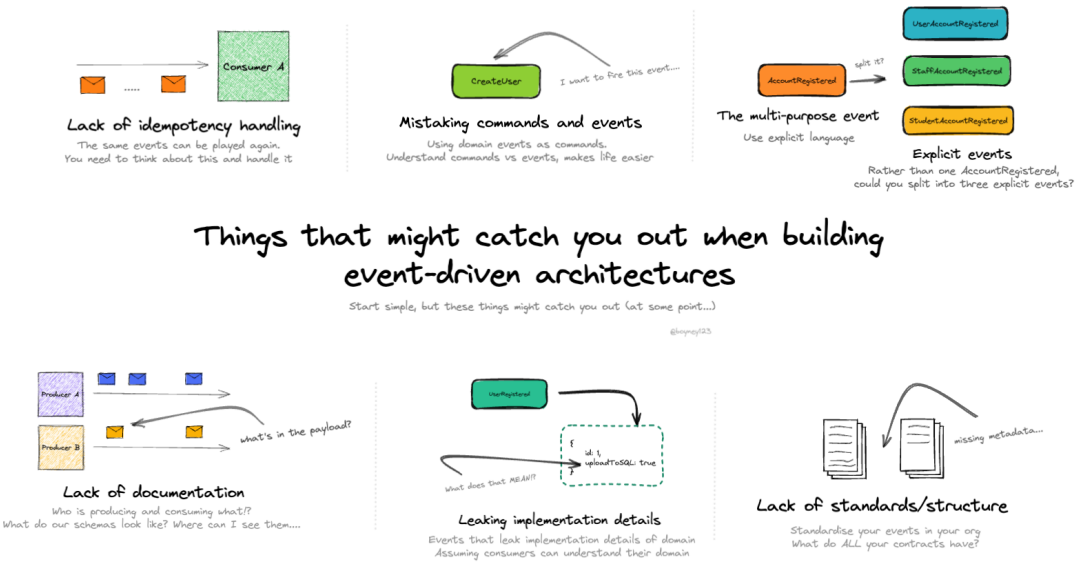


Figure 37: Things to consider when building EDA architectures

When you start building event-driven applications you start to write producers and consumers and you start to see value quite fast. Over time as more producers and consumers are added you will start to **face some common issues** *(these issues listed are all problems I have experienced and seen in the community)*

Lack of idempotency handling Consumers may process your events more than once (e.g. if events need to replay, or failures etc), your consumers need to handle this. You need to make sure your consumers produce the same outcome regardless of how many times it was called with the same event, having side effects in your consumers (different results) can lead to issues.

Mistaking commands for events An easy one when you get started, mistaking commands vs events. Here is a visual to help you understand the difference.

Multi purpose events When you start designing and implementing your events, it's easy just to add on that one extra field.... "what if we add a `type` field here", this works and might provide value, but over time your consumers might have a hard time understanding the **intent** of the event. Rather than having one event to rule them all, why not split them out? *Something to think about....*

Lack of documentation Let's face it, many people don't like to write documentation, especially as you start to build your EDA applications. Overtime as you add producers and consumers it can

be hard to keep track of who is producing what, and who is consuming what. Adding documentation can help. Here is visual with resources to help you.

Leaking implementation details When you have clear boundaries of services, it can be easy to leak implementation details of your service in your event. Make your events explicit, don't get consumers to guess what is happening, don't confuse them with implementation details.

Lack of standards/structure Overtime you might have 10s or 100s of events in your architecture, think about what goes into these events, maybe you might use CloudEvents or define your own standards, spend time here and think about it.

Extra resources

- Document your event-driven architectures - Visual here to help you understand ways to document your event-driven architectures.
- Identify domains and events with EventStorming - Think about how you are going to identify events in your system. EventStorming can help.
- Message delivery - How are your messages/events getting to your downstream consumers? Understanding this can help.
- Events are important - Event First Thinking - Treat events as a first class citizen in your architecture, doing this from the start can help you.
- Know the difference of types of events you raise - Notification events, Delta events, Event carried state transfer... what does it mean? Important to know.
- Commands vs Events - Quickly learn the difference between commands and events, 5min here can save pain later on.
- Passing events through context - Find your business domains and use events to communicate, you might need to transform them before consumers can understand them... that's OK, look at these patterns.

Ubiquitous Language

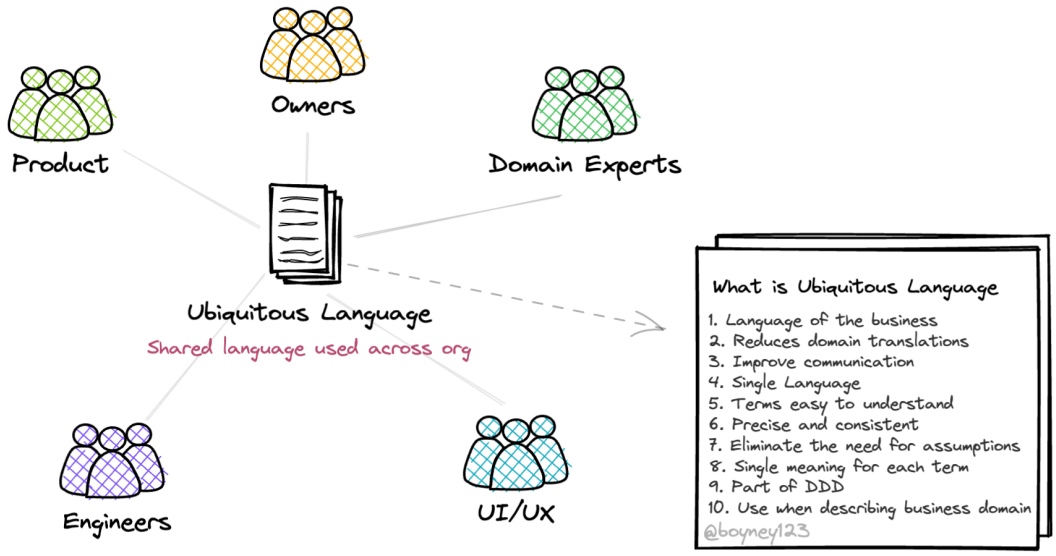


Figure 38: Ubiquitous Language

It can be time consuming or even frustrating when teams within an organisation are using terms to mean different things depending on the domain. For example a "policy" within one team could mean something completely different within another.... This leads to mental translations of models/business terms and can lead to confusion and assumptions.

Having a "Ubiquitous Language" means parties that communicate between each other speak in the same language. Define standards for terms, share them with each other and use them to describe business domain.

This is not directly associated to "event-driven architectures" but domain driven design plays a huge part in EDA. Having a shared language can help you name events, boundaries and build your EDA applications.

Extra Resources

- Best practices to design your events in event-driven applications - Blog post by Martin Fowler on Ubiquitous Language.
- Domain Driven Design Book - Domain-Driven-Design book, where Eric Evans talks about Ubiquitous Language.
- Learning Domain Driven Design - Notes in this design taken from the book "Learning Domain Driven Design" by Vladik Khononov.

Understanding Eventual Consistency

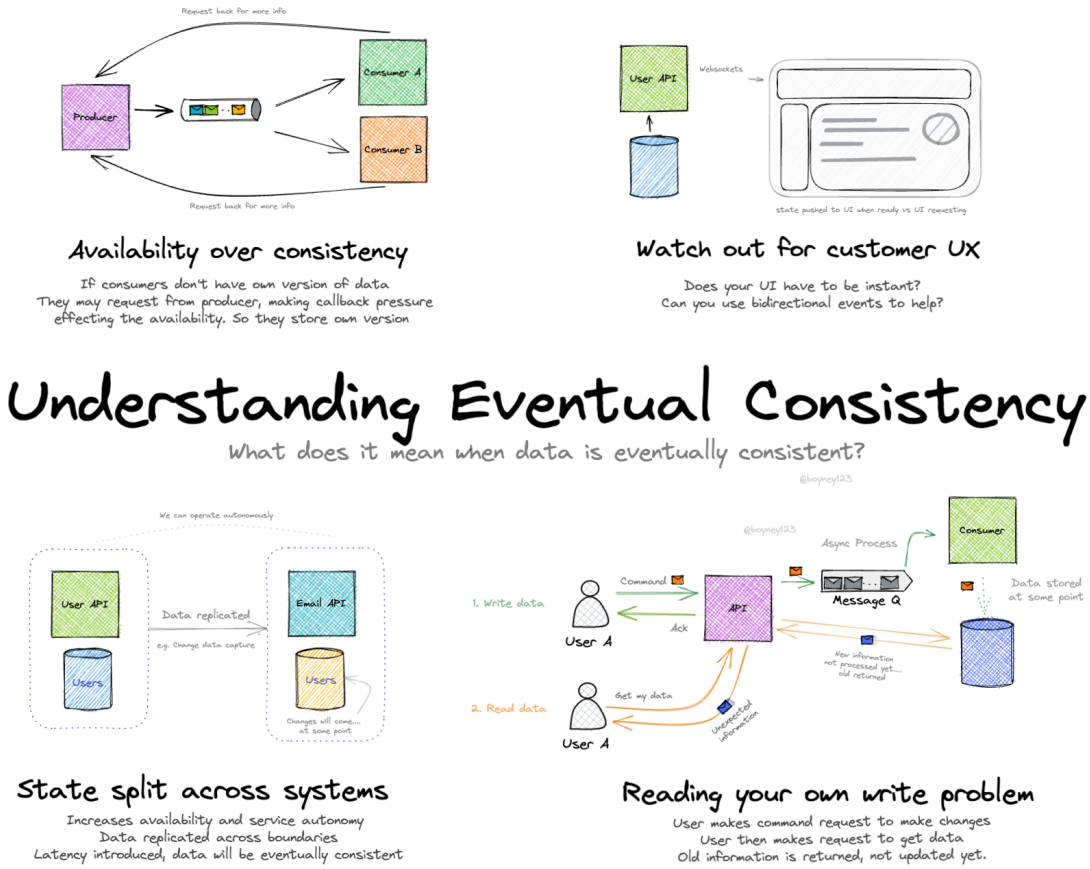


Figure 39: Understanding Eventual Consistency

"Eventual consistency is a consistency model used in distributed computing to achieve high availability that informally guarantees that, if no new updates are made to a given data item, eventually all accesses to that item will return the last updated value." [source]

Distributed state When we build distributed systems, there are times that state is distributed across our architecture (e.g. when we favour availability over consistency, e.g services have a copy of the data they are consuming vs requesting it from another service). This means data across your architecture in theory will be eventually consistent and at times the state will be inconsistent (as data is replicated across your architecture).

Users performing async actions Another common pattern is when users perform async operation. A command is sent to perform an action, and an async operation kicks in to process the action. The user then goes to read the information but it's not complete yet or returns old stale information, this means the task or data has not yet been replicated from where the user/api is reading it from.

When data is inconsistent it can affect your users experience (users reading their own writes), so it's worth considering UX patterns you can introduce to help (e.g webhooks back to client). Also, it's worth asking yourself does your business mind if these tasks are async and eventually consistent? Like most things, trade-offs need to be considered.

When building EDA applications, you will naturally find yourself dealing with patterns and experiences that are eventually consistent, it's worth keeping that in mind and creating or exploring patterns to help if you need to manage it better.

Extra Resources

- CAP theorem - Interesting theory about consistency, availability and partition tolerance, and that distributed data store can only provide two of the following.
- Trade-offs of event driven - More information from AWS to tell us about the trade-offs when going event-driven, more information on Eventual consistency

Understanding Idempotency

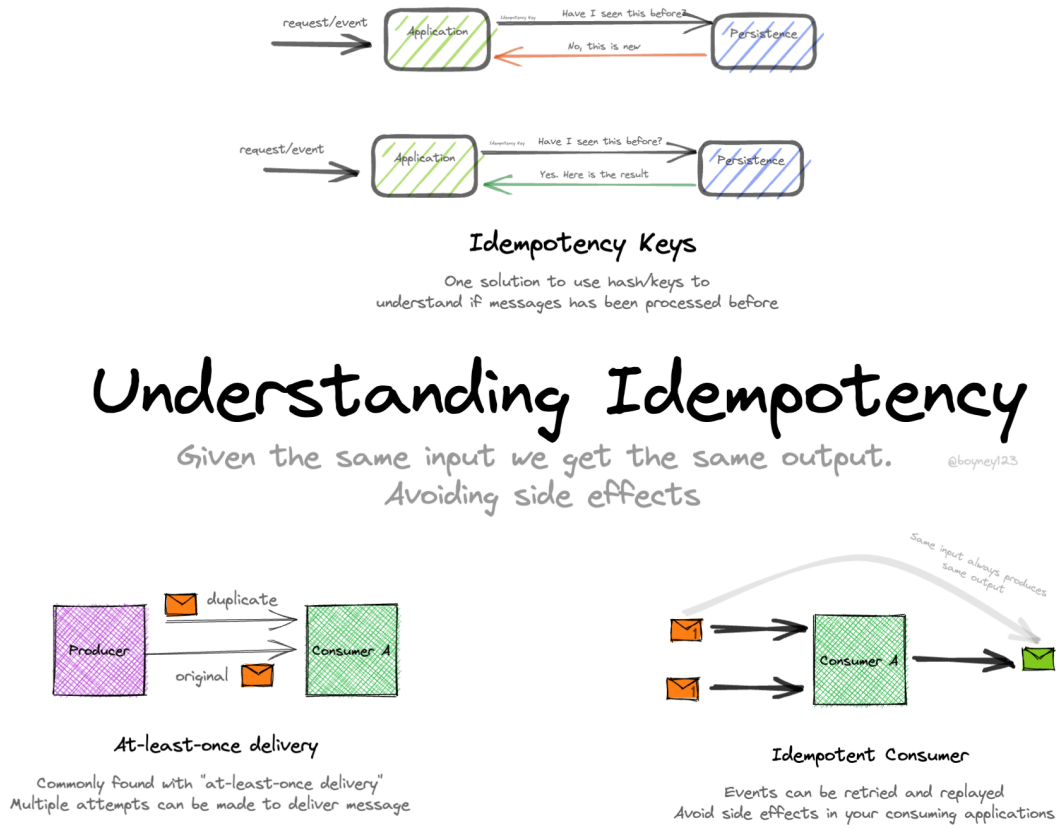


Figure 40: Understanding Idempotency

When building distributed message/event-based architectures it's important to consider and think about idempotency.

Messages/events can be replayed to your consumers, this means you need to handle the same message being played more than once. This might happen if you have failures, network issues or maybe you need to replay a bunch of events, either way **thinking about idempotency up front can help**.

Implementing idempotent consumers can be easier in some consumers than others depending on the logic inside your applications, but when you design or write your applications just think ***"What happens if this SAME event was to trigger again"***, what side effects will you have? Things will fail, helps being prepared for that.

Idempotency keys Some patterns to solve this issue to store the fact that the event has been processed before using idempotency keys, this is where you hash the events or part of the event,

and use persistence storage to store the fact the events has been processed (maybe with the result of the initial process). There are tools and libraries out there to help you with this, but it's worth exploring.

Extra Resources

- Message Delivery - Will your events naturally get replayed for you? Could depend on your broker of choice and how you handle messages/events, worth understanding at-most-once, at-least-once and exactly-once delivery.
- Good and hart parts of EDA - Understanding idempotency can take awhile to wrap your head around if you are new to it, but there are also some things to consider when building EDA applications (Error Handling, Debugging).
- Idempotent Receiver - Summary from the book enterprise integration patterns.
- Open Source project Powertools Idempotency helpers - Using AWS Lambda? Powertools is a great open source project with many different utilities to help you build performant Lambda functions. The project also can utils to help you deal with idempotency, worth checking out.

Understanding change data capture

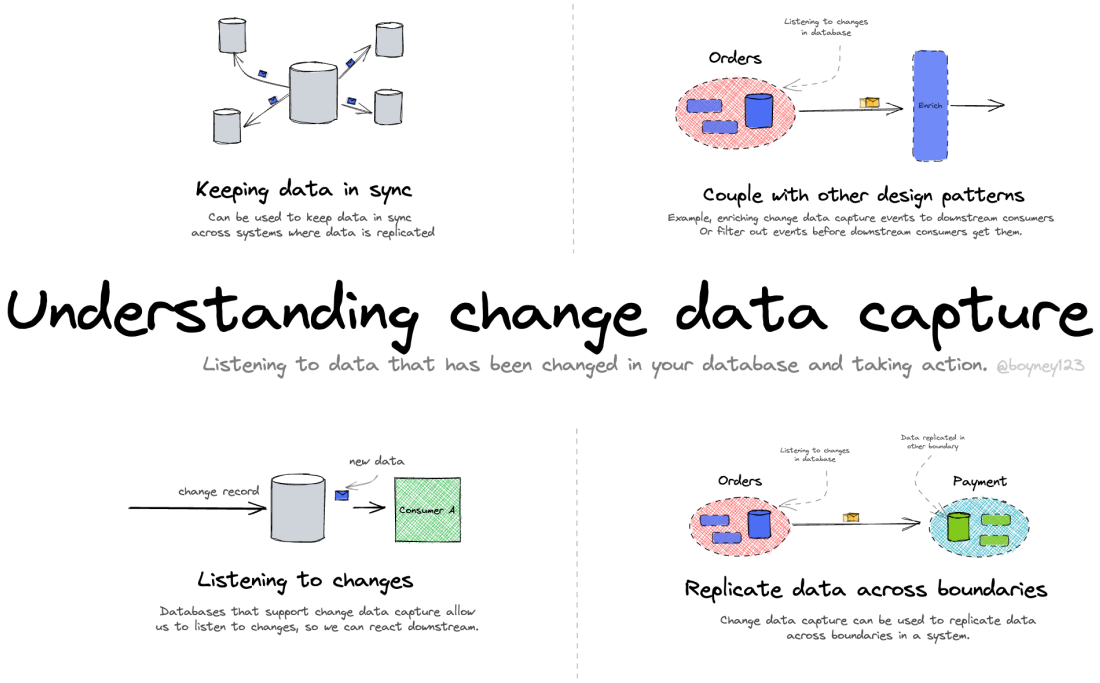


Figure 41: Understanding change data capture

Change data capture allows us to track changes made to a database and react.

We can observe changes written to a database and trigger downstream systems. This pattern is great for **event-driven architectures** as we can listen to changes and trigger downstream consumers or even replicate the data across our bounded context / microservices.

Listening to changes

- Change data capture allows us to listen to changes in a database.
- You can react to these changes to trigger downstream consumers or copy the data into other databases/views.
- It's quite a common pattern to listen to changes in a database, change data capture can help us write some resilient, and scalable event-driven architectures, raising events for internal use but also domain events for business consumption.
- Change data capture patterns can help us reduce the amount of custom code we need to write. E.g. Rather than raising events straight after a Database insert, we can insert and let services/databases give us the change data capture event.

- Great example of this is using DynamoDB streams. Data is streamed to consumers in near real-time.

Keeping data in sync

- Change data capture can be used to keep data in sync across many boundaries of your architecture.
- Many architectures have many data sources, change data capture allows us to listen to a change on the "leader" and push these changes to "followers".

Couple with other design patterns

- When consuming change data capture events, you may want to add layers in between the system consuming it, to enrich or filter the data.
- Example: if your consumer of the event requires additional information you can use enricher pattern to do this.

Replicate data across boundaries

- Your architecture may be split into many boundaries. You can use change data capture pattern to replicate data across boundaries making systems more resilient favouring availability over consistency.
- Replicating data may introduce eventual consistency, given no changes are made your database all listener's will be eventually consistent. This means data changes across your architecture is async and can take time, it's important to understand this.

Extra Resources

- Designing data-intensive applications - Book has a great insights into streaming and has a chapter around change data capture.
- Change data capture with DynamoDB - DynamoDB is a great NoSQL database that supports change data capture pattern. Many people are using this pattern to help scale their distributed architectures.
- Understanding bounded context - Your data may be replicated across your architecture, have you got the correct bounded context defined? Are you going back to producers to get information? Understanding bounded context can help.
- Migration with Change data capture - Maybe you are looking to migrate to an EDA architecture? Can you use change data capture pattern to help? Visual here to help you understand how you can use events to migrate.
- Unlocking value from your events - There is a huge amount of value in your events in your architecture, these include events from change data capture pattern. Can your business utilise these?
- Understand eventual consistency - If you are replicating data you may be favouring availability over consistency. It's important to understand eventual consistency and what it means for your architecture.

Understanding event delivery failures

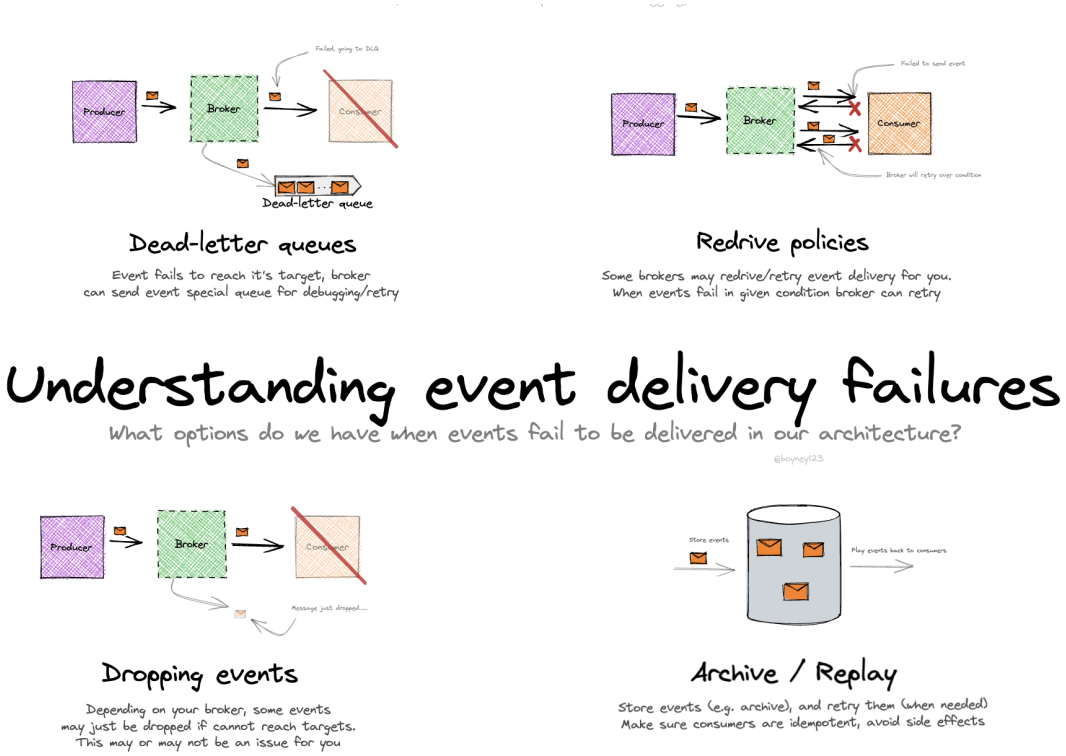


Figure 42: Understanding event delivery failures

When building event-driven applications it's good to understand what happens if your **event fails to reach consumers**, what your broker may do for you or what you need to manage yourself.

Dead-letter queue

- Place where events can go when failed to be delivered to consumer
- Events can fail to be delivered, do you want to store them? (before they are dropped)
- Use queue to debug errors or replay events back into system
- For more information you can read Dead letter channel enterprise integration pattern.

Redrive policies

- Some brokers may redrive (retry) events for you if they fail
- Example of failures may be due to network conditions or permissions
- Example of this would be Amazon EventBridge that retries event delivery for 24 hours with back off.

- Events could be dropped/lost (setup dead-letter queue to capture them)

Archive/Replay

- Store events that were raised and replay them into broker.
- Worth making sure consumers are idempotent as messages may be replayed more than once
- Outbox pattern can be used to store events before sending them.

Dropping events

- Some event brokers may just drop the event if it cannot process it
- Many brokers will retry given conditions, but worth checking and handling failures

Extra Resources

- Dead-letter channels - Interested to know more about dead-letter channels? Worth reading the enterprise integration pattern.
- Understanding Idempotency - Depending on your broker depends if events will get resent to consumers. Understanding idempotency can help.
- Things to consider when building EDA applications - Dead-letter queues / management is just one of them, there are more things to consider when building EDA applications, visual here to help.
- Message Delivery - What delivery method is your broker using? Understanding can help.
- Good and hard parts of EDA - What are the good and hard parts of building EDA applications? Visual for more information.

Understanding event streaming

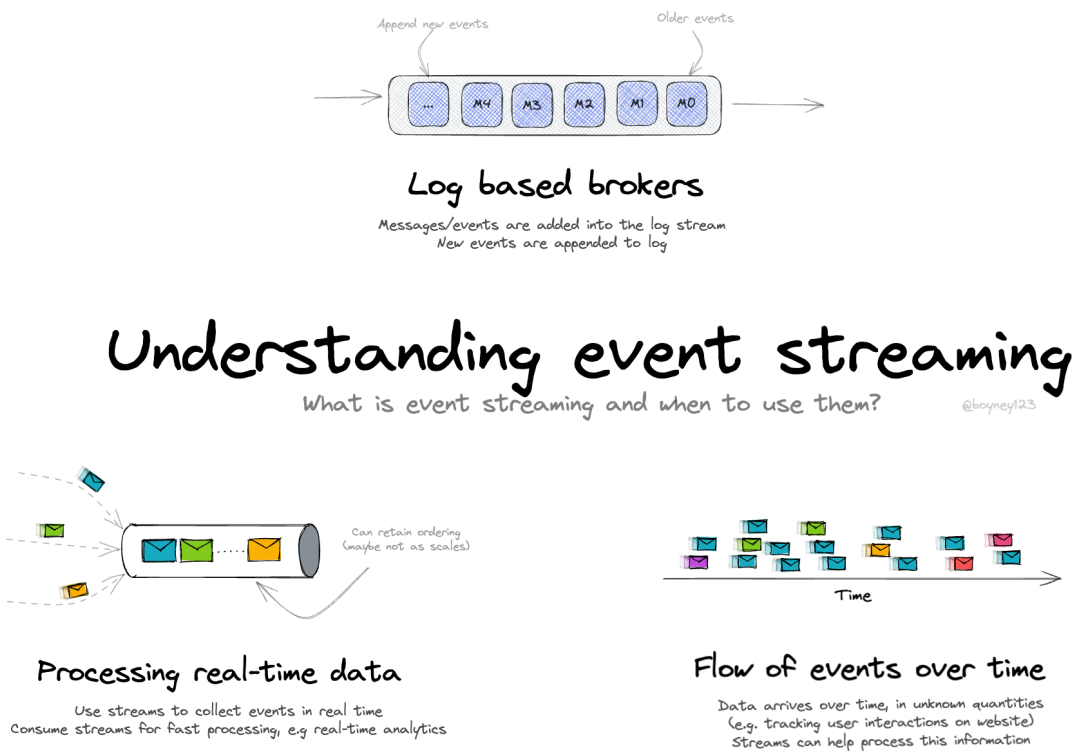


Figure 43: Understanding event streaming

What is event streaming? Think of event streams as a flow of events traveling through a river. Each event is captured and can be processed by downstream consumers.

Event streams can be great for processing real-time data.

When we build applications there are times where the amount of data to process is unknown and we want to capture it (e.g. user interactions with a shopping cart online), we can collect this data and then process it in real-time downstream (e.g. for analytics or reporting for example).

Data loses value over time. Many companies want to process information in real-time to make decisions. Event streaming can help.

Event streaming use cases Some common examples where you may find event-streaming is handling IOT events, gaming, real-time applications or using streams to collect user information for analytics/metrics downstream.

You can also connect streams together to process information (Event stream processing), streams

read output from other streams and can process this into new information.

Log based brokers Some brokers use a log-based approach to capture messages/events in an append only system. Think of this as a ledger, new information is added onto the stream, and consumers can consume this information from either the start or choose a starting location (usually an offset). Examples of log-based brokers are Amazon Kinesis Data Streams or Apache Kafka.

Extra Resources

- Designing data-intensive applications - Book has some great chapters on event streaming.
- Building an EDA application, streaming is just part of it - There are many other parts to building event-driven applications, streams are just part of it. This visual helps you identify others.

Understanding publish & subscribe messaging

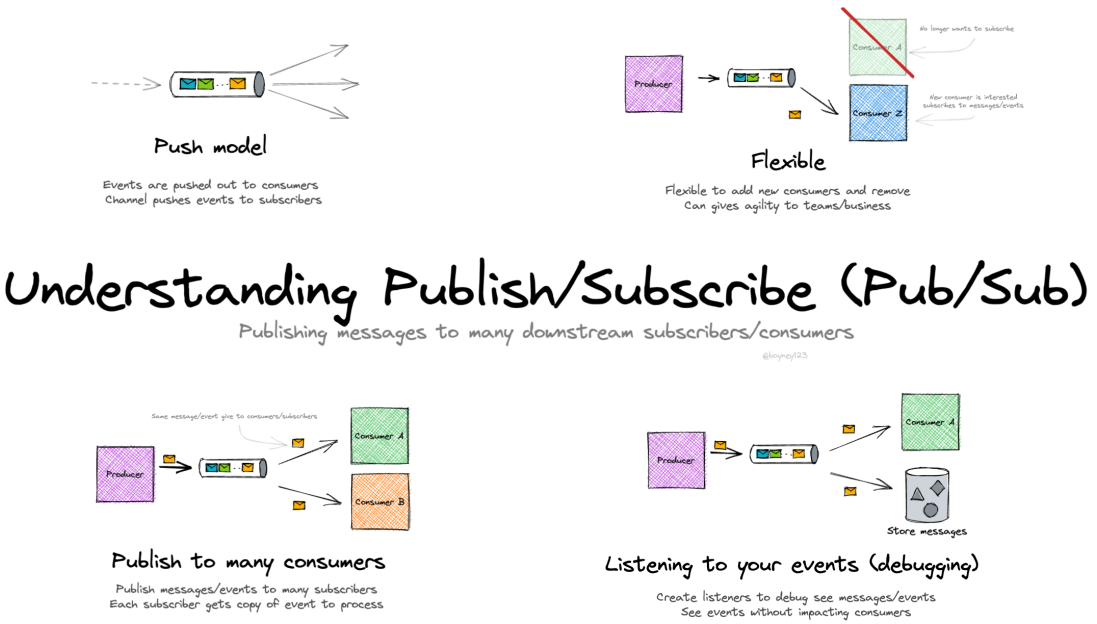


Figure 44: Understanding publish & subscribe messaging

Pub/Sub channels allow you to publish messages to many consumers that are interested in that message. Producer publishes and consumers subscribe.

Publish to many consumers This pattern allows your producer to publish messages to many downstream consumers. Consumers get their own copy of the message to process.

Listening to your events As consumers are independent from each other (own copy of the message), you can create new subscribers onto the channel and use this for debugging. An example of this would be to create a new subscriber to an event, store the information somewhere or log it out, this way you can see all events going through the producer's channel.

Flexible Consumers come and go, high chance your producer does not care. This gives teams the flexibility to add consumers as business requirements change or even remove them.

Push model With pub/sub messages/events are often pushed to downstream consumers (rather than consumers having to listen and pull events of a queue/channel).

Durable Subscriptions At times you might have subscribers that are still interested but "inactive" (no longer receiving messages), and gets the messages back when they reconnect, this is known as the durable subscriber, if you are interested it's worth checking out that pattern.

Extra resources

- Publish-Subscribe Channel - Publish Subscribe channel from Enterprise Integration Patterns, worth a read to dive deeper.
- Durable Subscriber - Interesting pattern when subscribers are "inactive" and want to process messages they missed from a pub/sub point of view. Worth reading and understanding.
- Conway's Law and EDA - When creating pub/sub patterns you will have many producers and consumers, understand how Conway's law can effect all this with this visual.
- Message translator pattern - Before consuming events in your subscribers/consumers do you want to transform your data? Might be worthwhile? Dive deeper with this visual.
- Claim check pattern - When sending events, sometimes they can be too big for your broker, or you want to keep them small. Store the information with a key and let consumers get it back with the Claim check pattern.
- Content enricher pattern - Before consumers get your events can you implement some middleware to enrich them?
- Event Types - You will be sending messages/events throughout your application, know the difference between the types of events you are sending, your contract will impact your architecture choices.
- Message Brokers vs Event Brokers - Message Queues, Event Brokers what does it mean? Where does pub/sub fit into the picture of EDA. Visual to help you.

Understanding stream and discrete events

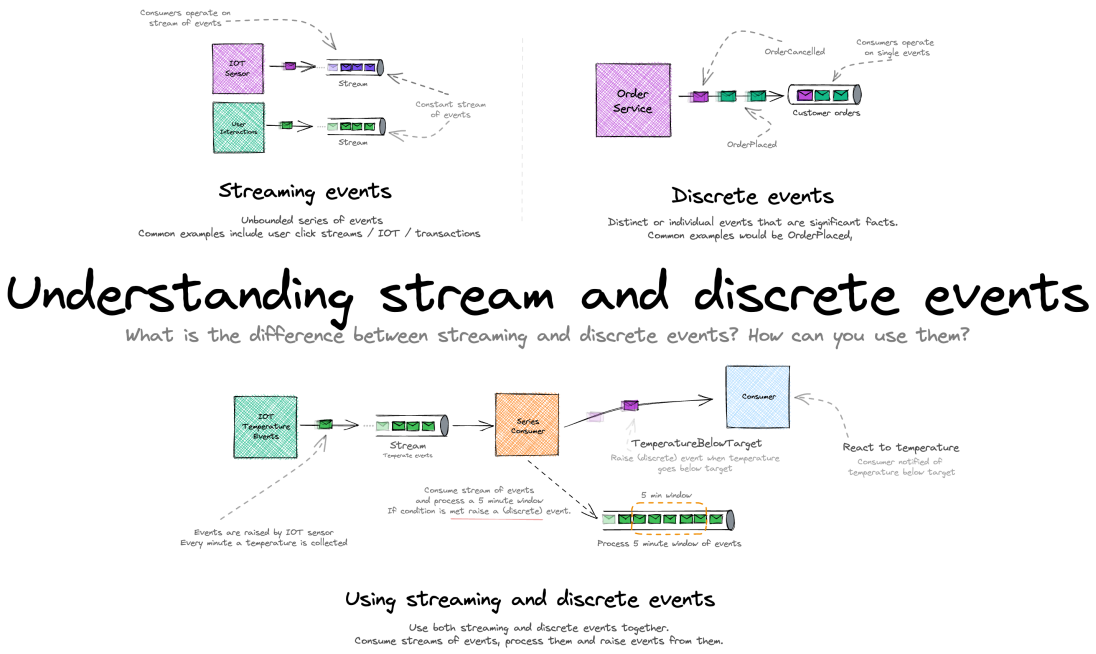


Figure 45: Understanding stream and discrete events

When building event-driven architectures your architecture may consist of streams (series) of unbounded events (events that never end), or discrete events (events that are facts, they happened). Depending on your use-case will depend on which you may have, and many folks will have and need both. Often starting with discrete event use cases though (where consistent and easy event subscription, routing, and filtering are common requirements).

When trying to understand the difference, you need to understand what you want to act on and process. For example if have an IOT temperature sensor that raises events, you may want to consume these events and process them in "micro" batches, let's say every 5 minutes (processing a stream of events). Once we process these events, we can add business logic to determine if something of interest has happened, an example could be that the temperature fell below our threshold we set, then we can raise an event (discrete event) to notify downstream consumers of something significant that happened.

Streaming events

- Think of a stream of events as **unbounded data**, they are continous and may never end.
- Processing these events can differ from processing discrete events. For example you may be interested in batching these events (e.g by time, collection, user), perform stateless (counting)

or stateful (joins) operations, and then raising events from what was processed.

- Common examples of streaming events would be IOT (telemetry) sensors, Click streams on a website, credit card transactions.

Discrete events

- Think of discrete events as significant (important) **facts that have happened**, and you have downstream consumers that want to act on this information.
- Example would be an OrderPlaced, CustomerMoved, PaymentRejected events.
- Discrete events can be raised from business applications, such as an order service in a restaurant, or from processing a stream of events for analytical purposes. If you process a batch of events from a stream, you may want to analyze this information and rise an event to let the system know something has happened.

When to use streaming or discrete

- Many event-driven architectures may use both streaming and discrete events, it really depends on your consumer semantics. What are you trying to act on? What information do you have? What is your business use case? What do your consumers need e.g., event filtering/routing, error handling, programming language support, knowledge around a particular solution or make the system opaque to decrease coupling
- Streaming events allows you to capture an open ended amount of events/information you may want to act upon - often the value is not within a particular event, but in the series/group of related events (“high volume, low value“)
- Discrete events allows you to rise facts in the system of things that have happened, these facts can from various sources, and one of them might be processing a stream of events hitting certain business criteria. Discrete events itself have value to the consumer, i.e., they represent a significant fact/change consumers (subscribers) will act upon

Extra Resources

- Dive deeper into event-driven architecture - Want to learn more about event-driven architecture? There are over 40 visuals for you to dive deep and learn.
- Batch processing vs event streaming - A further dive into what are event streams and what is batch processing.
- Understanding event streaming - Want to continue to learn about event-streaming? Understand real-time data, flow of events and log based brokers.
- Use EventBridge Pipes and Event Buses to process discrete events from many event sources, such as AWS events, Amazon Kinesis, and Apache Kafka
- Serverless Office Hours: Integrating EventBridge with Apache Kafka

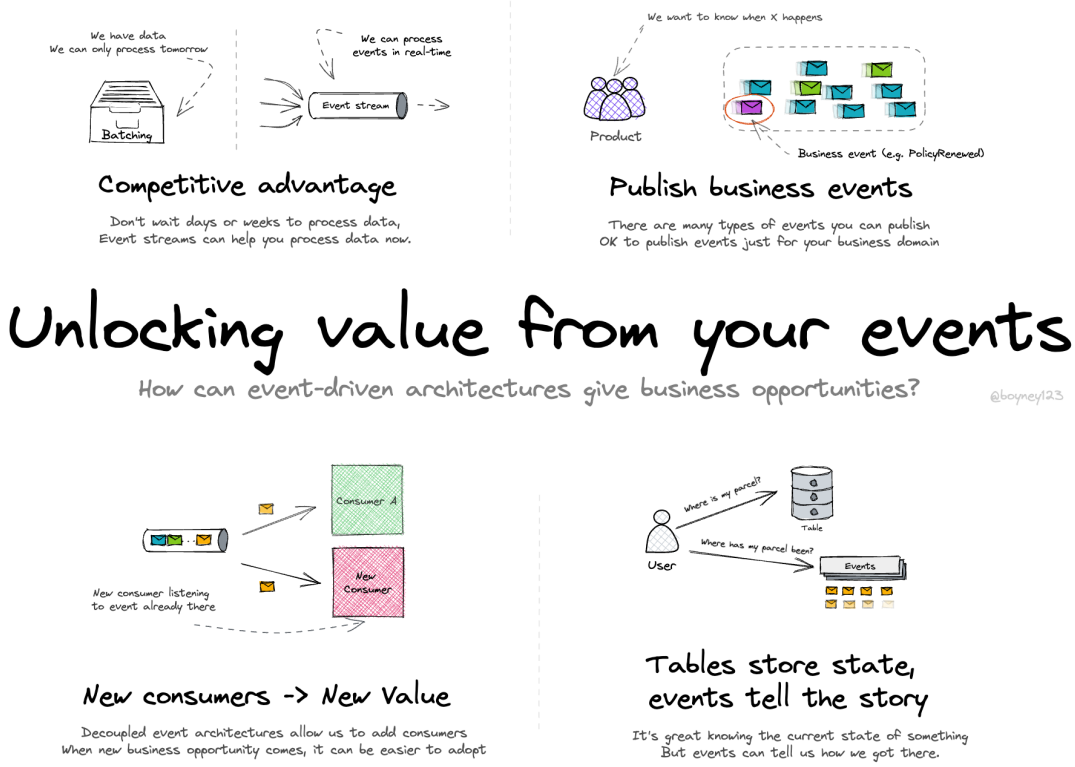


Figure 46: Unlocking value from your events

When we build event-driven architectures we use events to communicate between services and domains, these events are often used to trigger async processes downstream, and we can use event-driven architectures to create decoupled and scalable solutions.

It's also important to know that the events we use to communicate can also be **valuable for businesses** and create new opportunities (e.g. Using events to process data in real-time).

Competitive advantage Many companies rely on batching to process data and generate reports **after events occur**, event-driven architectures can give organisations options to process information **when events occur**. For example, companies are using event streaming to process events in real-time for downstream consumers (e.g. Reporting). If we move data processing closer to the time it occurs, we can get more value from it.

Publishing business events There are many types of events when building event-driven architectures, and business events are part of that. We use events to communicate between systems, but we can also use events to notify parties of critical business metrics we can use to make decisions.

New Consumers = New Value Producers are decoupled from consumers, when new business opportunities arise we can add consumers onto events already there. Today you may not see business value in certain events, in the future the value may unlock, having this producer/consumer relationship can help.

Tables store state, events tell the story Many applications query some database for the state of a given entity, for example a query to find the location of a package right now for a given user. This is great, but how we can determine where the parcel has been? We can use events to tell the story. Keeping an event log can help us understand how things ended up the way they are.

Extra Resources

- Designing data-intensive applications - Book has some great chapters on event streaming.
- Types of events - There are many types of events, understanding them can help.
- Learning Domain Driven Design - Some notes taken from the book "Learning Domain Driven Design" by Vladik Khononov.

Using events to migrate from legacy architectures

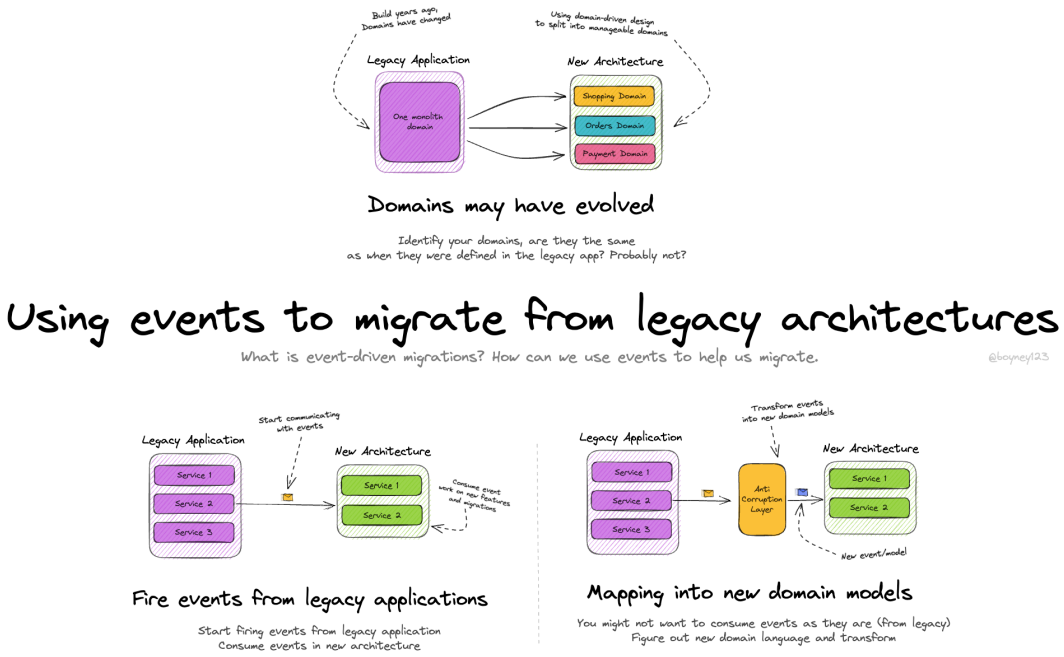


Figure 47: Using events to migrate from legacy architectures

When we build event-driven architectures we use events to communicate between services and domains, these events are often used to trigger async processes downstream, and we can use event-driven architectures to create decoupled and scalable solutions.

It's also important to know that the events we use to communicate can also be **valuable for businesses** and create new opportunities (e.g. Using events to process data in real-time).

Rather than going big bang migrations that could take months or years, slice up your architecture/features and delivery them over time (commonly seen in strangler pattern). We can use events here to help us, and move us towards an event-driven architecture.

Fire events from legacy applications

- Integrate your legacy application with your event/message broker
- Requires up front cost, but allows you to start publishing events from application
- Downstream consumers (new architecture) can consume events
- Cloud example pattern could be using `PutEvents` from Amazon EventBridge to publish events from legacy application into AWS, where new consumers can react.

Mapping into new domain models

- Careful not to take "legacy events" as they are, you may want to map them into a new format/domain for your architecture
- Make sure legacy implementation details in events are not integrated within your new architecture (unless you identify that the models are similar)
- Use context mappings to map events from a legacy language into a new one. You have options here: Conformist pattern, anti-corruption Layer, open-host service.

Domains may have evolved

- Your legacy application may have been written years ago, things change. Your models/domains may have changed from inception years ago.
- Use techniques like Event Storming to highlight existing behaviours of your system and new domains you want to evolve into.
- You don't have to mimic the same language in your new architecture. You may want to start using bounded contexts and ubiquitous language away from your legacy application (if it makes sense)

Extra Resources

- Minimum Variable Migrations - Some of these ideas were inspired by the work Ben Ellerby is doing with Minimum Variable Migrations.
- Find events in your exisiting application - EventStroming can help you identify events for new applications, but also systems that already exist, this can help find events in your legacy application.
- To conform or not conform to legacy events? - Careful taking events from legacy applications as they are (conformist pattern), you may want to map. This visual can help

What are events?

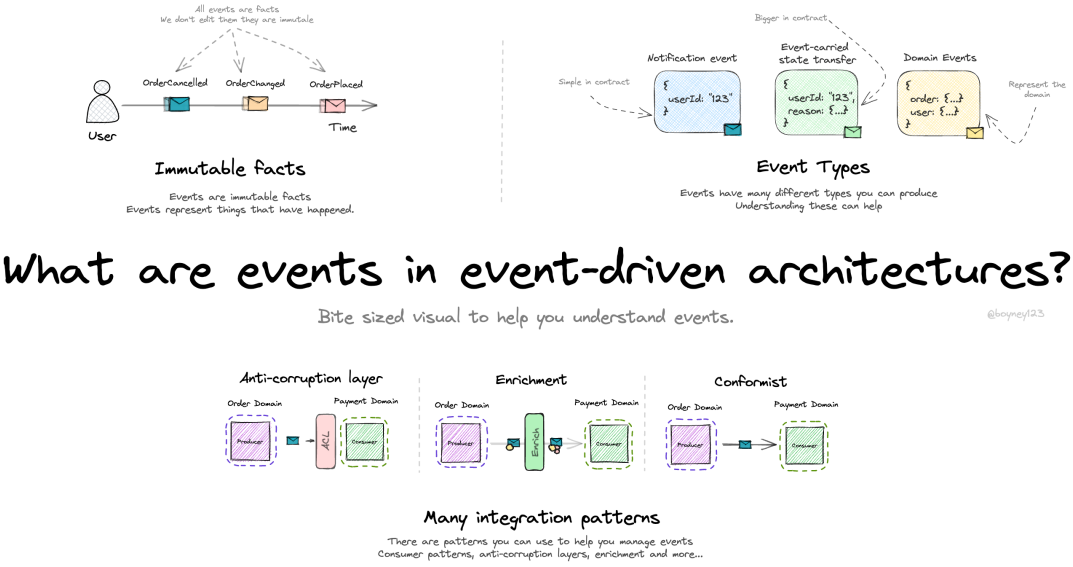


Figure 48: What are events?

Events may seem simple, raise something and react somewhere, but as you dive deeper into event-driven architecture and start building solutions you soon realise that there is much more to events that you initially thought.

Understanding the core concepts, event types and exploring integration patterns with events can really help you understand events at a deeper level, which can help you when building event-driven solutions.

Immutable facts

- Events are immutable facts. Things that have happened that cannot be undone or changed.
- Events are great a representing real-life scenarios. Events happen all the time, everywhere. The time you played that song, took the bin out, ordered something online, cooked food, at most situations events are happening.

Event Types

- When you start, you may just be publishing any kind of event without much thought. This works initially but can lead you to problems with inconsistent events, poor event design, migration and much more (link to video to help understand).
- Events come in many different sizes and patterns, many developers building event-driven solutions use various different event types based on their use case.

- Examples of these are notification events (keeping contracts simple), event-carried state transfer (putting more information into the events), domain events(events representing your domain), delta events (events that give the difference between old and new), and many more...
- Understanding these event types can help, and there are more resources below to dive deeper.

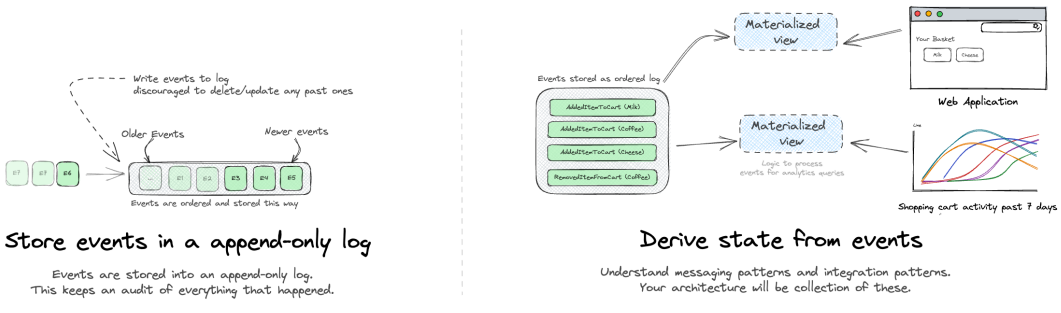
Many integrations patterns

- Integration patterns give us ways in which we can interact, consume and manipulate information before consumers get it.
- Anti-corruption layer (ALC) is a popular pattern that engineers use to map consumed events into events/models that the consuming domain understands. For example consuming an `OrderPlaced` event within the `Payment domain`, the payment domain may want to map this event into a structure/schema that the payment domain understands.
- Enrichment allows events to be enriched with information before downstream consumers consume them. This pattern allows producers to raise simple events, and consumers get information they may require even if it is not on the original event.
- Conformist pattern is when consumers conform to events as they are. No enrichment, no mapping, nothing. They take the event and consume it. This can be great for domains that life close together, but be careful not to conform to implementation details exposed in events.
- Enterprise Integration Patterns is a great resource to dive deeper into messaging integration patterns. Worth reading and re-reading.

Extra Resources

- Enterprise Integration Patterns - Fantastic resource to dive deeper into integration patterns, a must read if you want to learn more.
- Messages between bounded context - Another visual to help you understand how to integrate bounded context with messages and what patterns to help you.
- Event first thinking - A talk I gave at GOTO in 2022 talking about event-first thinking. I talk about event design, trade offs and the importance of event-first thinking.
- What do you mean by "Event Driven?" - Martin Fowler dives into event-driven architecture and talks about the different types of events
- Many different event types - Dive deeper into event types, what they are and what they mean.
- Content enrichment pattern - Visual to help you learn more about the enrichment pattern and resources to dive deeper.
- Internal vs External Events - Visual to help you understand the difference between internal and external events

What is Event Sourcing?



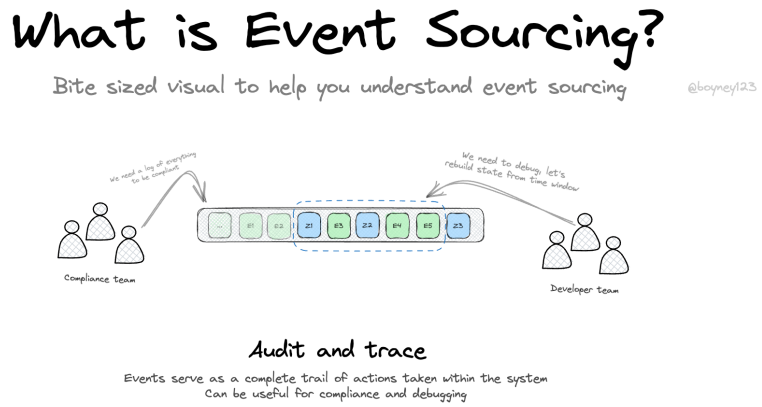


Figure 49: What is Event Sourcing?

Event Sourcing is a pattern the stores events in order, in a append-only log.

This can enable various use cases like keeping audits of changes, compliance requirements, deriving state from events, replaying and debugging.

Many applications query for the current state and we mutate that state but sometimes we need to know the story/history of how the current state got there. Storing events using Event Sourcing provides a pattern to help us understand how the current state of the application got to where it is.

As events occur within the system, they are captured and stored. Application state can be calculated using these events, even if you have a clean starting point, you can see previous events, and calculate the current state.

Store events in append-only log

- At the heart of event sourcing, you store your events in an append-only log.
- You read/write from this log and it is discouraged to delete/update any past events.

- Any changes to events, are just new events onto the log, that way all mutations are captured in the log.
- Great example of this is accounting ledger. Accountants want to track transactions made and these are recorded.

Derive state from events

- As the data is captured as events within a log, this log can be viewed/processed to calculate state.
- The target state may depend on the application querying the data, so often materialized views are created for applications.
- Applications query the views to get the information they need. This can be cached or snapshots may be used in event stores to help with performance at larger scales.
- As you see in the visual, the analytics platform and web application both have different requirements and state to display. They talk to different views to get this information, all derived from the event log.
- Common pattern for this is CQRS (Command and Query Responsibility Segregation)

Audit and trace

- As events are stored, it opens up possibilities for auditing and traceability.
- Depending on your use case event sourcing can be a great pattern to help if you need to get an audit log of certain events within your architecture.
- As the events are stored and materialized views can be used to query the events, various teams can read the data.
- An example could be developer teams may want to replay events helping debug systems, compliance teams may use events for reports or product owners may want a new feature that allows users to see historic transactions within their banking account.

Extra Resources

- Martin Fowler gives us an overview with examples of Event Sourcing - Back in 2005 Martin Fowler released this post still relevant today. He gives us an overview of Event Sourcing with various examples. Great if you want to dive deeper.
- Beginner's Guide to Event Sourcing - Great guide to dive deeper into Event Sourcing, CQRS, Domain-Driven Design, and much more.
- Microservice Pattern: Event Sourcing - Great website to learn more about Microservice patterns, here is one about Event Sourcing, just in case you still need to learn more!
- What goes into your events? - So you want to try Event Sourcing? But what do you put into your events? Here is a visual I created to help you understand what goes into your events, with something I like to call event-first thinking.

- Commands vs Events? Why do you need to know? - Super relevant for Event Sourcing. There is a difference between commands and events. What are they? Why does it matter? This visual can help you understand more.
- Understanding Eventual Consistency - So you raise events, store them and want to read them. Reading this information will be eventual consistent. What does that mean? Here is a visual to dive deeper and help you understand.

Why use message brokers?

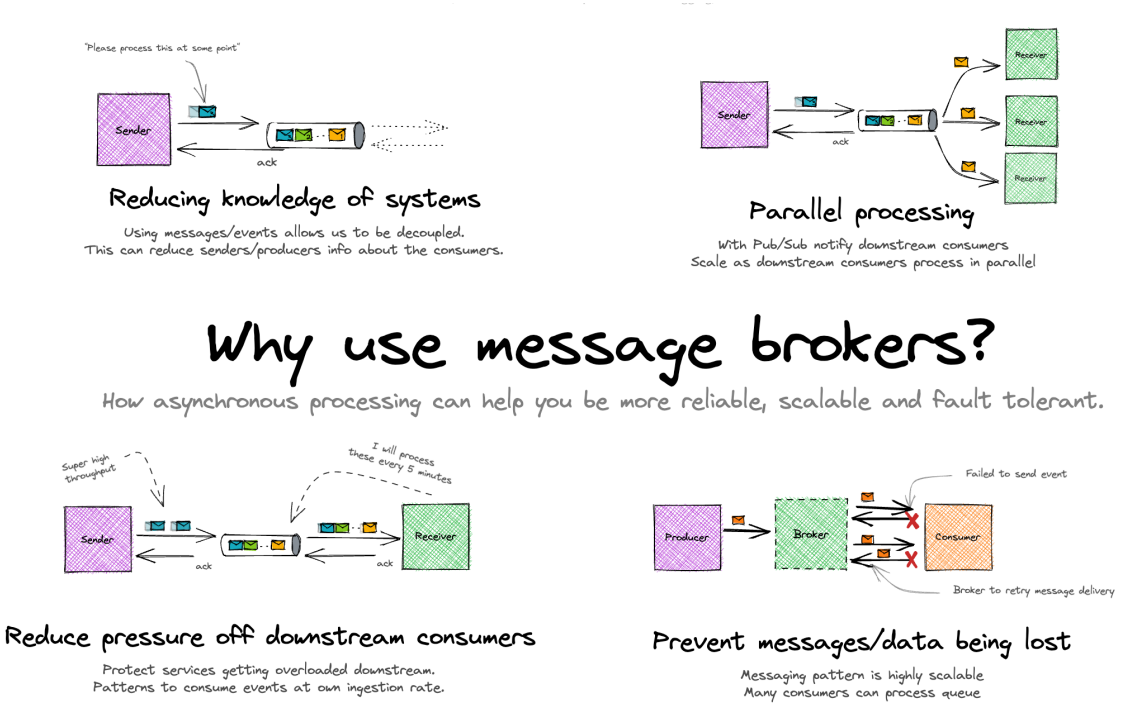


Figure 50: Why use message brokers?

Reduce pressure off downstream consumers

- Many people use message brokers to reduce back pressure from downstream services. The sender puts messages on the queue, and consumers can pick up these messages and process them in the batch size they want and the time they like.
- You can use message brokers to make sure that downstream services do not get too overloaded, which can improve system reliability.
- Example of this could be to use an SQS queue, to handle many messages, and a consumer to process these messages and delivery information to a third-party API.

Prevent messages/data being lost

- Many brokers offer the ability to retry messages/events if they fail to get processed or delivered. This can help prevent any information being lost.
- If your broker does offer retry and replay, you want to consider idempotency as your consumer may be triggered more than once, and you don't want any unwanted side effects.

- This could be a great pattern, as you broker may do the heavy lifting for you (retry/reprocess), many are configurable and if all fails you can decide what you want to do with the messages after the retry period (example drop them or store them for later processing)

Parallel processing

- Some brokers offer pub/sub patterns allowing you to send events and notify downstream consumers. This pattern allows you to notify downstream processes that something has happened. Many downstream systems can listen to these events.
- If you are using message queues, you can still have many consumers processing messages from the queue, this allows you to scale processing downstream.

Reducing knowledge of systems

- Using messages/events to communicate between systems/services can help us decouple our architecture.
- Producers may not need to know about downstream consumers, this gives the producers the ability to isolated and focus within its own domain/boundary.

Extra Resources

- Designing data-intensive applications - Book has some great insights into streaming, and messaging. Highly recommened if you want to dive deep.
- Fundamentals of Software Architecture - A great book to learn more about the fundamentals of architecture, goes into event architecture and many patterns.
- 65 messaging patterns - Great resource to dive deeper into many different patterns. Highly recommended.

Learn event-driven architecture today

If you want to learn more and get started building event-driven architectures on AWS, here are a few resources that can help you.

EDA Guide on Serverlessland.com Serverlessland.com hosts over 400 AWS Serverless patterns, 60 Step Functions workflow patterns and over 40 serverless code snippets, we also have a new EDA section to help the community learn more about building event-driven architectures. If you want to know more you can visit https://serverlessland.com/event-driven-architecture/intro

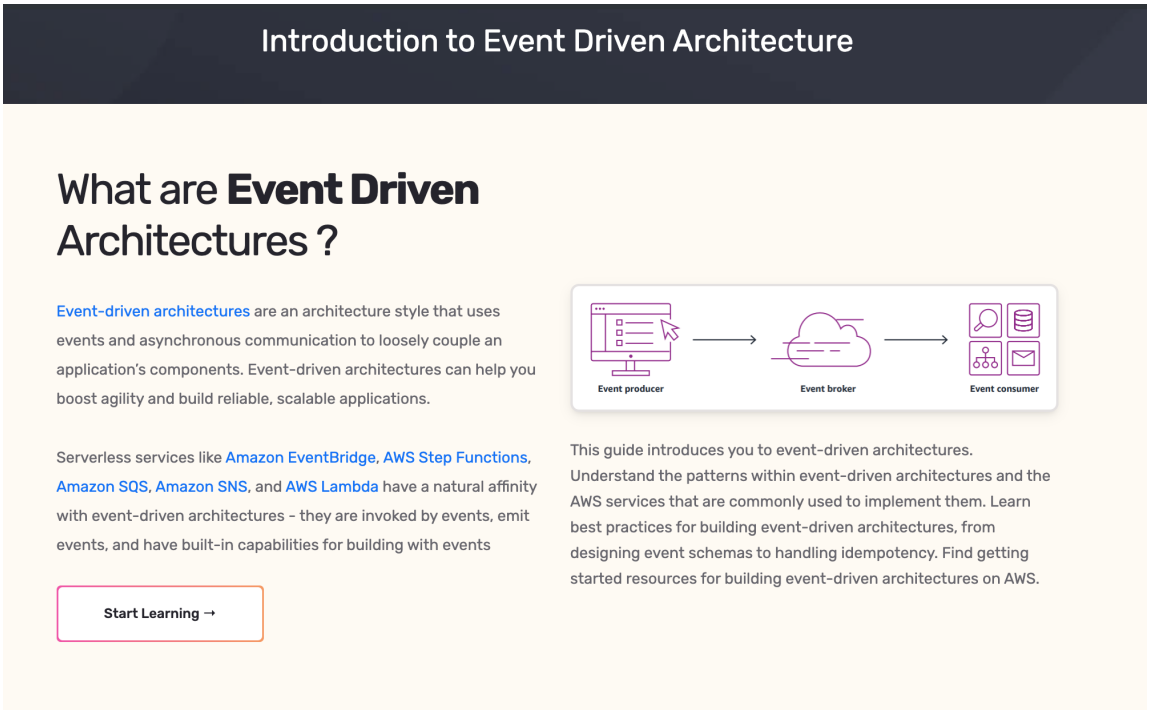


Figure 51: Learn event-driven architecture on Serverlessland.com

30 Days of Serverless and EDA For those who want to get hands on building serverless event-driven-architectures on AWS, we have created a new program for 30 days of Serverless. These are a collection of videos we have put together to help you learn serverless and event-driven-architectures from the ground up. If you want to learn more you can visit https://serverlessland.com/reinvent2022/30dayssls

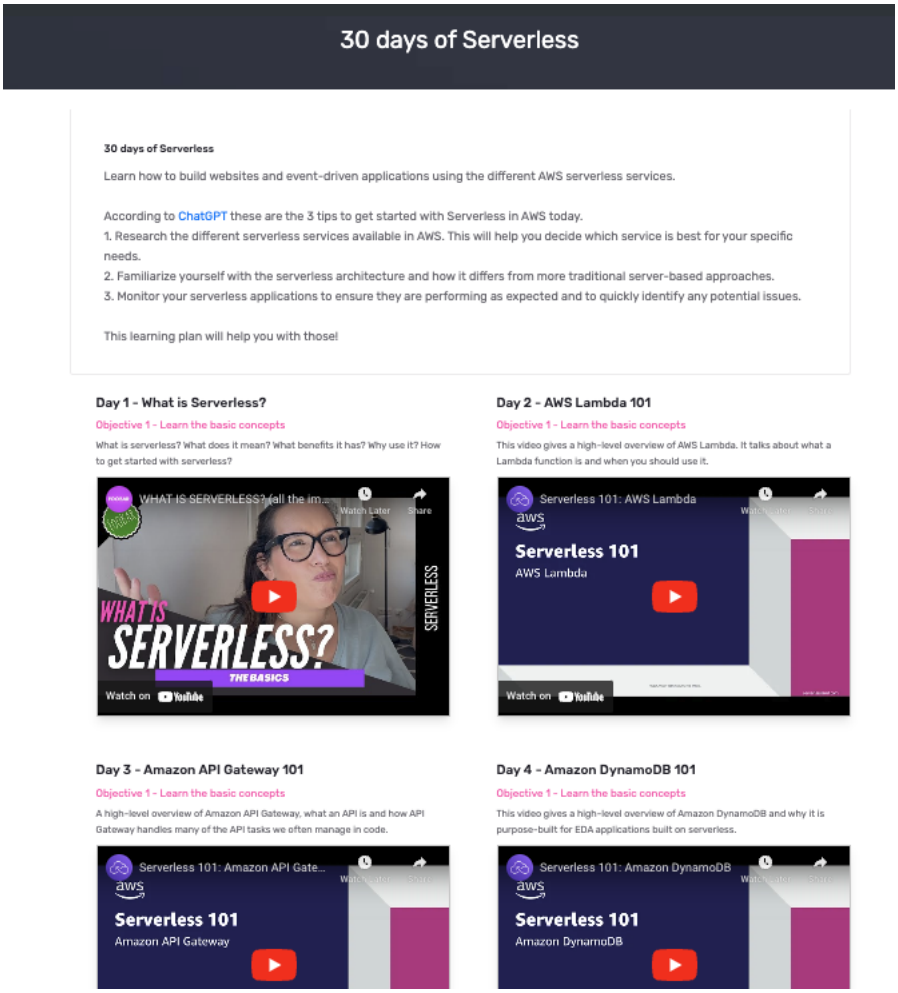


Figure 52: Learn event-driven architecture on Serverlessland.com

Summary

EDA visuals are small bite sized visuals about event-driven architectures. You can use the visuals to help you get a high level overview of areas of event-driven architectures, and use the resources to dive deeper.

The visuals in this document are from https://serverlessland.com/event-driven-architecture/visuals and this document will be generated again with every new visual added.

Hopefully you find this content useful, and feel free to connect with me if you want to learn more.

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