Resource Sector

The Business Case For An Event Mesh

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The Business Case for an Event Mesh

1 The Resource Sector

Survey any group of senior executives who run mining or oil & gas companies[1] about their challenges and aspirations and you will likely hear common top priorities. In terms of **business strategy**, high on the list will be capital allocation, portfolio management, asset life, environment, safety, extracting shareholder value, EBITDA and protecting their license to operate. In terms of **execution strategy**, top priorities include technology innovation to improve exploration, production efficiency and optimization, and end-to-end value chain integration and automation.

These execution strategies help drive a **lower unit production cost**, which is vital to being competitive. For example, at most shareholder briefings there will likely be references to the current average price of a barrel of oil or a tonne of iron ore. This underscores a key challenge: business strategy success relies on extracting a sustainable profit from a volatile commodity price. Applying the execution strategy to reduce unit production cost is one of the most important components in achieving this. Lowering the unit cost increases the chances of sustainable profit even when commodity prices fall.

So, we should ask the question: how can IT infrastructure materially help lower unit production cost? We explore this below.

Dig or drill a bit deeper (pardon the pun) into the executive's strategies, and **digital transformation** becomes a central pillar. Digital transformation means introducing efficiency-increasing capabilities like remote operations, autonomous haulage, sustainable locomotion and supply chain automation. Just like the banking industry first did decades ago (and are re-visiting now), the mining and oil & gas industries are undergoing a "digital renaissance" where "digital operations," "digital mines," and "digital twins" are the new templates for optimization. From pit-to-port, or across the end-to-end value chain, digital transformation that integrates and automates will increase efficiency and deliver a competitive benefit because it lowers the unit cost of production.

Technology enablers appear early on in the business and execution strategies. Underpinning digital transformation are things like industrial IoT, digital sensors, emitters, transducers, actuators, drones and automated robotics. They are physical things that identify or act on a state of something, an opportunity or a threat, and allow the company's operations to make a decision and take an action that will improve the situation at that point in time. This will be done en masse in production. To achieve this, the new technology will interoperate with new analytics, artificial intelligence, machine learning, mobility and augmented reality capabilities. This will provide the necessary production scale of situational awareness, rapid decision-making and immediate actions. Most likely, the new capabilities will leverage the cloud in many of its different forms and definitions. Cloud will be a means of driving business agility because it allows companies to innovate rapidly.

1 Throughout this document, a broad (perhaps loose) definition of "resource sector" is used. For our purposes here, we include companies operating in mining, minerals, and oil and gas, including coal seam gas, oil shale and unconventional petroleum resources. This is because we believe the value proposition described can apply to all these businesses.

2 Integration, Layers, and Complexity

If we look at mining in the resource sector, we see discussions of Mining 4.0 and technical models, and perhaps high-level reference architectures that recognize the roles of ERP, Mining Execution Systems (MES), SCADA, PLC and control systems. For oil & gas operators, the MES might also be called a manufacturing execution systems layer or a well construction execution system model. Regardless of terminology, the model will recognize how "layers" of ERP, MES, SCADA and control systems will interoperate with maximum safety, security, and efficiency. At the ERP layer, global software vendor SAP is likely a strategic provider with modules that may be addressing areas such as supply chain, materials and workforce management.

Overlay that with a multitude of digital technologies coming from strategic equipment and application providers (each with vertically integrated "stacks"), and the landscape quickly becomes complex. This overlay could include (just as examples) digitally enabled and operated equipment from strategic manufacturers like Caterpillar, Komatsu, and Atlas Copco; solutions from the likes of Schlumberger and Rockwell Automation; and platforms from providers like OSIsoft. The number of cloud solutions available continues to grow, and the public cloud options such as AWS, Azure, and GCP fuel agility. However, each option has its own integration toolkit, so users need to beware of single-source lock-in. The number of systems and amount of data on-premises remains large now and in the future. There is also the notion of edge data and the processing of it that has emerged.

All of this raises the crucial importance of another capability which has already been mentioned: **integration**. It is integration that allows automation across the end-to-end value chain, as well as across the architectural layers, technology silos, clouds, devices, and geographies. It facilitates and promotes innovative execution that moves the dial on efficiency and the unit cost of production. Keeping in mind our other strategic drivers like safety and environment, integration also needs to be done securely, reliably, and at scale. The rewards, risks, challenges, and benefits associated with integration become magnified with digital transformation. The fact is, digital transformation relies heavily on integration.

3 The "Events Lens"

If new challenges are created by the growing importance and complexity of integration, which helps enable digital transformation, how do innovative resource companies respond?

One way is to view the end-to-end value chain from the perspective of events. Events are simply things in business that happen or don't happen (i.e., a missed deadline). Events are the "atoms" of everything that happens in a business, regardless of whether it is digital. Events are also things that prompt (or at the very least invite) further actions or response.

The resource business is a massive series of events. The optimization of the pit-to-port supply chain, the value chain spanning exploration, and well development/operation and pipeline involves millions, or more likely, billions of events per day. Identifying, linking and acting on events in real-time can be a game-changer for efficiency and optimization, which helps to drive production volume and a lower unit cost. Here are some examples:

- The on-schedule shipment of the right grade of iron ore to a customer in Asia;
- The avoidance of a worker fatality through the timely sending of an alert from a wearable sensor/emitter;
- An unusual tidal condition is predicted at Port Headland, or the category of a hurricane in the Gulf of Mexico is upgraded;
- The arrival of a crew of shift workers at a remote location need clearance in an IT system to enter the facility;
- A beneficiation process is delayed or missed due to unexpected equipment failure;
- The avoidance of an environmental incident because a digital sensor alerted an emergency team to a sudden state change in time to intervene;
- The safe inspection of a remotely-operated machine in an inaccessible or dangerous location with a drone camera;
- The avoidance of two weeks of lost productivity by the early identification and intervention over an out-of-range temperature on a locomotion component or pressure on a submersible pump;
- The vital spare equipment part that arrives for a repair has an invalid serial number for the required use;
- A three-year high in the company's share price is reached;
- Or, something that didn't happen when it should have: another system or a human operator is alerted that a key sensor reading wasn't received by the expected timeframe; or: a worker did not show up with the necessary sub-assembly.

These are all examples of important events. Some are good and some are bad.

Proactively "joining the dots" of events across systems, processes, and geographies allows resource companies to better exploit opportunities and mitigate risks. Effectively identifying, managing, and acting upon these types of hypothetical event examples, and doing so at scale and through automation, can profoundly improve the company's ability to innovate, optimize and drive supply chain efficiency.

When looking at things through the "events lens," events become the lifeblood of value chain productivity and efficiency, and a strategic key to achieving volume and unit cost targets. They can also contribute to other KPIs involving safety, environment, capital management, EBITDA, and greenhouse gas emissions. Detecting, sharing and acting upon events can positively impact all of these.

If events are the efficiency lifeblood, then having an event-driven architecture (EDA) can act as the IT "nervous system." EDA is used and supported by many IT industry proponents, ranging from respected analysts at Gartner and IDC to software giants like SAP and countless integrators. For example, Gartner believes that "by 2020 event notifications will drive 60% of business transactions in new digital business solutions"[2] and that "Event-driven microservices are the optimal software design model to deliver digital business agility."[3]

An important thing about events and EDA is that the value of an action or response to an event has a shelf-life. The longer an opportunity or threat is not acted upon, the more the value of a response diminishes. That is because there is a compounding lost opportunity when innovation is delayed and the seriousness of a problem grows. The expression "chain of events" fits well here.

2 Source: Gartner "Innovation Insight for Event Thinking" 5 Oct 2018
3 Source: Gartner "Top 10 Strategic Technology Trends for 2018: Event-Driven Model" 8 March 2018, Yefim Natis, David Cearley, Mike Walker, Brian Burke

4 Responding vs. Reacting

As the old proverb goes:

"*For the want of a nail the shoe was lost,*
For the want of a shoe the horse was lost,
For the want of a horse the rider was lost,
For the want of a rider the battle was lost,
For the want of a battle the kingdom was lost,
And all for the want of a horseshoe-nail."

Wouldn't the commander in the field have benefitted from having an event-enabled alert system to warn about that first small event that started the bigger "chain of events" that then led to the catastrophic failure? This would have empowered them to thoughtfully respond rather than abruptly react.

In modern EDA, actions have a corresponding timeframe and, for many, real-time is a necessity. If left unattended to, several of the risk event examples listed earlier could escalate, triggering an increasingly impactful "chain of events" that would ultimately lead to negative outcomes that parallel the quote.

It is possible to imagine a potential chain of events where we substitute the lost horseshoe nail with a small weakness in a tailings dam structure, a seismic movement, or both. In the case of O&G, it might be a failure of a valve, allowing an unexpected build-up of pressure. At the other end of the chain, after the eventual advent of a significant environmental or safety incident, the "kingdom that is lost" is the revocation of a license to operate in a key geography, or even a workforce fatality.

That's on the risk side. Focusing more on opportunities, take for example a hypothetical submersible pump used for production. Now, add a scenario. By detecting and analyzing events, a specific combination of technical lead indicators is identified, allowing the prediction of the pump's likely failure-time with some accuracy. Knowing this, the analytics can then decide the optimum time to shut it down for preventative maintenance, thereby avoiding a lengthy repair. The analytics might also take into account an external event, like an associated process needing to be complete on another piece of equipment before shutting down the pump.

The second decision concerning timing needs to be made not from the perspective of the cost of the maintenance, but from the perspective of minimizing the overall supply chain disruption or down-time – the lost production. Shut it down too frequently, and the production is sacrificed. Shut it down too late and a failure occurs, resulting in greater lost production due to the extra repair time.

Decisions surrounding this will leverage IIoT, predictive analytics, AI, ML, and robotics systems. As a result, the best action gets taken by triggering other events – human alerts, system processes or machine operations. When any similar combination of technical lead indicators is detected, operational systems will automatically decide, prescribe and initiate this same optimum timing for intervention.

The same might also apply to when a failure is not looming. Let's say the equipment's manufacturer recommends periodically taking a pump out of operation (perhaps prematurely so they can service it). Your own reliable analytics might tell you the optimum time is in 2-month intervals and a small, highly-reliable consumable part is a week from arriving into stock. The operational decision you make impacts production up-time.

If performing the preventative maintenance on the hypothetical pump when your AI/ML application says so saves premature downtime (and this gets magnified across all pumps in the production chain), there's a good chance it will add up to a big hypothetical production-time number. When applied consistently in real-time in an automated regime across all key equipment, operations and geographies, the compound beneficial impact to unit cost of production becomes even more compelling.

5 Data and Event Silos: Barriers to Efficiency

Events are also a way of breaking down silos, data islands, or barriers to performance. The systems that manage, for example, that hypothetical fleet of Caterpillar equipment, and those managing Atlas Copco equipment (and similar systems and equipment from other strategic manufacturers) might each be well vertically integrated. But how might they benefit from a broader, global, horizontal and vertical event sharing mesh?

And what if that mesh could reliably and efficiently exchange and route events across multiple open standards like MQTT, AMQP, REST, JMS and WebSocket, and diverse programming languages?

Such a mesh would make it easier for events in the first manufacturer silos' management system(s) to be published, routed and shared with any other systems, processes, people and equipment-silos in the value chain that are impacted by the originating equipment's performance, behaviour or output.

Importantly, the publish/subscribe capability of the mesh would mean the producer of the relevant events doesn't need to worry about the other systems; it just needs to publish its events. The other systems only have to subscribe to the same events which would then automatically and efficiently get routed to them for consumption and action.

This event distribution mesh will intelligently and reliably route events to applications, other systems, people, processes and devices:

- No matter where they are located, on the mine site or drilling rig, in the on-premises datacenter or remote operations center (ROC), at the IIoT edge or in the cloud;
- Across the silos of vertically integrated manufacturer "stacks," in SAP, in the MES or across other reference architecture layers;
- All helping to enable holistic, end-to-end improvements to the value chain.

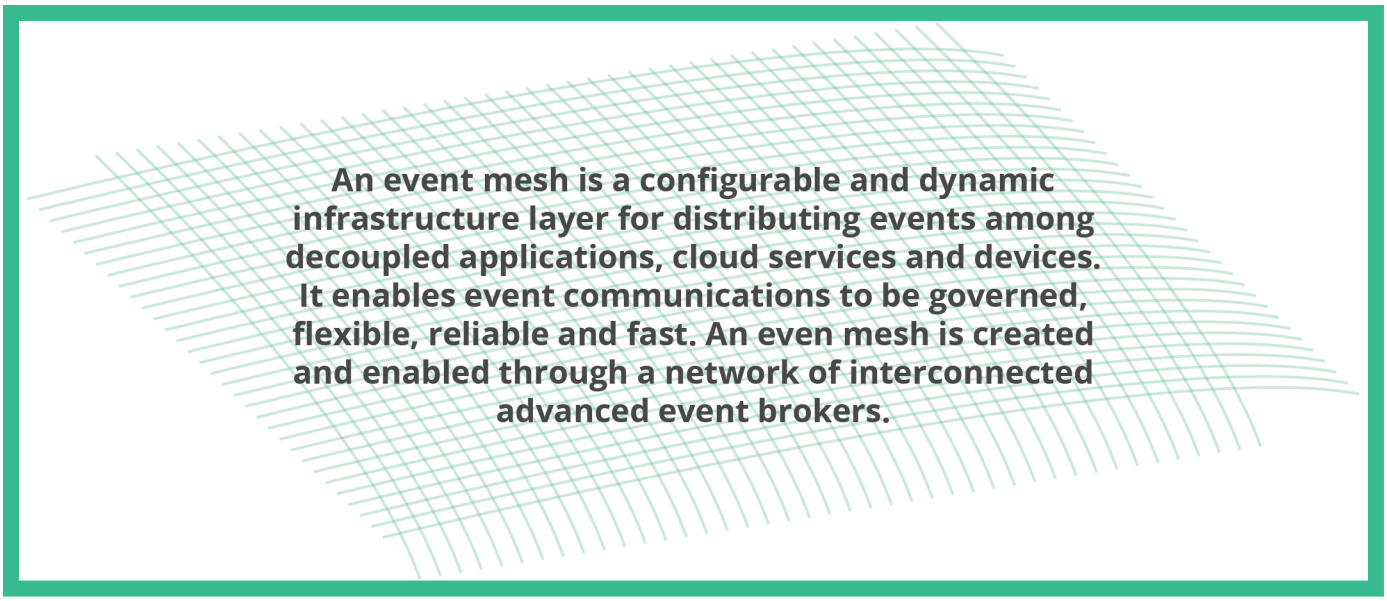
6 The Event Mesh

The capability we are describing is called an "event mesh," and the IT industry is increasingly embracing the concept of and benefits from the use of an event mesh. Gartner notes:

"Event mesh provides optimization and governance for distributed event interactions. The distributed optimized network of event brokers facilitated by the event mesh infrastructure aims to enable a continuous digital business native experience."[4]

An event mesh is not a product but can be thought of as an outcome and an architectural layer that drives higher capabilities.

4 Source: Gartner "The Key Trends in PaaS and Platform Architecture," 28 February 2019, Yefim Natis, Fabrizo Biscotti, Massimo Pezzini, Paul Vincent



7 What makes an event mesh strategic?

An event mesh is comprised of and is built on a network of interconnected advanced event brokers. But what are the features that make one important and advantageous enough to be strategic to the resource sector? For starters, the event mesh should:

- Be based on and embrace open standards. This is not necessarily the same as being open source. It will achieve the following:
  - By being open and open standard-based, it will enable the event mesh to overlay and interconnect across the broadest set of applications, systems, silos and technologies to maximize its enterprise utility; and,
  - It will provide the company implementing it a viable and practical exit strategy to replace the event mesh broker component if for any reason the broker or its supplier fails to perform or meet the expectation of the customer and requirement.

The event mesh brokers should support open standards such as AMQP, MQTT, REST, JMS and WebSocket, as well as open APIs such as Paho and Qpid. Extending this, APIs should cater for C, .NET, iOS, Java, JavaScript, JMS, Node.js and popular frameworks like Spring.

The organization considering building an event mesh capability should consider its component brokers to be their “integration Swiss Army knife” so as to maximize their return on the investment made, and to achieve maximum reach across the enterprise and IT landscape.

Example use-case: A supply chain workforce solution running on 6,000 portable tablet devices or mobile phones may need to use REST to communicate with the client app. But connecting to IoT sensors and emitters might be better suited to using the MQTT protocol, while talking to back-end ERP systems might more suitably require AMQP or a legacy technology such as JMS or MQ. A multi-protocol, multi-language advanced event broker, serving as the building block of the innovative resource company's event mesh, will simplify this and allow the developers and delivery team to focus on disruptive solution features that will drive operational efficiency and customer-centricity.

The event mesh should also:

- Offer the maximum range of deployment options. Across mine sites, drill platforms, datacenters, ROCs, the cloud, in-vehicle and at the edge, it should be able to be consumed as:
  - A cloud service;
  - Installable software using the most current platform patterns for Kubernetes, Docker, PaaS, iPaaS and public and private cloud services; and,
  - A purpose-built hardware appliance to meet the most demanding performance, throughput, low latency and regulatory requirements. This also delivers infrastructure efficiency and security flexibility.
- Be feature-rich. Along with supporting open standards, it should provide:
  - Exchange patterns including pub/sub, request/reply, queuing, streaming, fan-out, fan-in;
  - Guaranteed and best-effort delivery;
  - Asynchronous API and communication support;
  - Event replay;
  - Sophisticated event routing including wildcards for messaging topics and REST URLs;
  - WAN optimization; and,
  - Be accessible to developers as a free software download or cloud service, yet also provide a seamless growth path to the upper end of the mission-critical, enterprise-level performance and reliability spectrum.
- Be simple to deploy, operate and manage. Despite its functional richness, it should:
  - Not require excessive infrastructure, nodes, separate components or management complexity and overheads;
  - Not require tooling to support multiple protocols, public clouds or PaaS/iPaaS combinations[5];
  - Allow the mixing and matching of cloud, software and hardware deployments;
  - Be manageable through a single-pane-of-glass console across the entirety of its interconnected network of public and private cloud and on-premises event broker instances;

- Be scalable, reliable and resilient, offering multiple quality of service and availability options, including 99.999 availability while carrying suitable tiered levels of direct specialist product support and committed product lifecycle management; and,
- Be proven in mission-critical applications where safety, environment, performance and business reliance are non-negotiable.

8 Proof-point examples

A Solace-enabled event mesh is proven and successful as:

- The events layer underpinning SAP's Cloud Platform Enterprise Messaging;
- The event distribution fabric for the entire safety-critical, North American air traffic management (ATM) and air navigation service provider (ANSP) ecosystem of producers and consumers;
- The strategic real-time event broker network for connected vehicles in some of the largest global commercial and consumer motor vehicle manufacturers;
- Part of the industry 4.0 platform of the world's most dominant component manufacturer;
- The manufacturing fabric for one of the world's most iconic and consumer mobile device brands;
- The option of choice for a majority of the top ten financial exchanges and trading platforms; and,
- The "performance & reliability beast" processing upwards of 90 billion events per customer per day for some of the largest telecommunications providers and credit card brands in the world.

9 The Business Case

9.1 The cost of an event mesh

A Solace-enabled event mesh can, starting with a free version, be deployed and incrementally expanded at a small fraction of the total cost of ownership of traditional legacy integration platforms and ESBs, and for less than open-source-based, bespoke solutions. The reasons for this boil down to choosing open standards (which are replaceable) versus open-source (which, despite the moniker, may not be easily replaced). Another reason is the simplicity and the proven industrial reliability and capacity to scale. Targeted proof of concepts can be delivered in days or weeks by small, agile teams.

5 Solace has customers who use event mesh to perform cloud arbitrage, such is the flexibility and avoidance of technical lock-in that event mesh can provide. Cloud arbitrage is the dynamic shifting of workloads across clouds to leverage relative price, performance and feature advantages of respective providers Cloud Arbitrage with Solace.

9.2 The value

Given the low cost to build and operate an event mesh, and the capacity for it to (1) assist and accelerate digital transformation, (2) improve integration, automation, and efficiency and (3) ultimately reduce unit cost of production, using a Solace-enabled event mesh is an opportunity innovative resource companies must consider.

10 Where to get the Solace-enabled event mesh

Solace's advanced event broker products (and the resulting event mesh) are freely accessible for developers to use and download, both as a free cloud service at **solace.com/cloud/** or by downloading installable software and a Docker image or one of our machine images. Solace's PubSub+ Standard Edition is completely free.

Explore the options at **solace.com/downloads/**.

11 Have questions?

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Appendix A – An Event Mesh Built On Solace

1 Solace and SAP

To assist the reader in better understanding the relevance of how a Solace-enabled event mesh would fit within a large O&G or mining company, it is worthwhile giving some brief focus to a particular aspect of Solace's offering.

Software giant SAP is a strategic customer of Solace, but the relationship goes further than just being a customer. Within SAP, Solace is deployed in several use cases (all use cases can be discussed under NDA). Most notable is the SAP Cloud Platform, where Solace provides the implementation of the SAP Enterprise Messaging Service.

SAP Cloud Platform Enterprise Messaging is a cloud-based messaging service that enables asynchronous event-driven communication between all kinds of applications and microservices using open APIs, standard messaging protocols and popular message exchange patterns. SAP's website refers to SAP Cloud Platform Enterprise Messaging as:

"A cloud-based messaging and event-enabling service for decoupling application logic and developing microservices."

This description itself, we think, gives validation of the event mesh proposition and the "event lens" perspective.

The platform on which leading companies build their event mesh is called Solace PubSub+. "Pub/Sub" because that is an abbreviation for publish and subscribe – one of the premier architectural patterns for modern digital transformation projects across private and public clouds, on-premises and edge IoT, and which is particularly well-suited to microservices and CI/CD pipeline delivery.

The "+" in PubSub+ is there to indicate that, as well as publish and subscribe, Solace's event broker also supports other diverse patterns such as queueing, request/reply and streaming, and with common deployment, APIs and administration. Think again of the Swiss Army knife metaphor.

SAP uses Solace PubSub+ to enable event-driven messaging in SAP Cloud so that SAP customers can easily create seamless data streams between SAP Cloud and legacy systems.

Solace is active with SAP in this initiative and expects SAP to leverage more event mesh capabilities in the future. At the least and in the current state, it would mean any SAP customer using Solace PubSub+ would be able to use the same client code to integrate to either customer-hosted Solace instances or SAP Cloud Platform Enterprise Messaging with no rework – as they use the same API. In the future, it may even be possible to peer SAP Cloud Platform Enterprise Messaging with Solace PubSub+ instances anywhere in the world.

In addition to this, and considering our relationship with SAP, we've established a technology partnership with ASAPIO. ASAPIO has a product that "event enables" an on-premises SAP R/3 instance. This could allow events to be synchronised with other applications either on-premises or in the cloud, including via SAP Cloud Platform.

2. Solace-Enabled Event Mesh in a Resource Company: Future State

So what might an event mesh for the innovative mining or oil & gas enterprise look like at a very high level? Here's an example.

This event mesh will act as a next-generation, enterprise-wide integration platform for oil & gas and mining. Applications aren't constrained to specific protocols; IoT devices can connect via MQTT just the same as business application microservices can connect using AMQP, JMS or .Net. Once published to the event mesh, the events are all consistently routed to any subscriber. Furthermore, the mesh routes securely and in the most efficient manner.

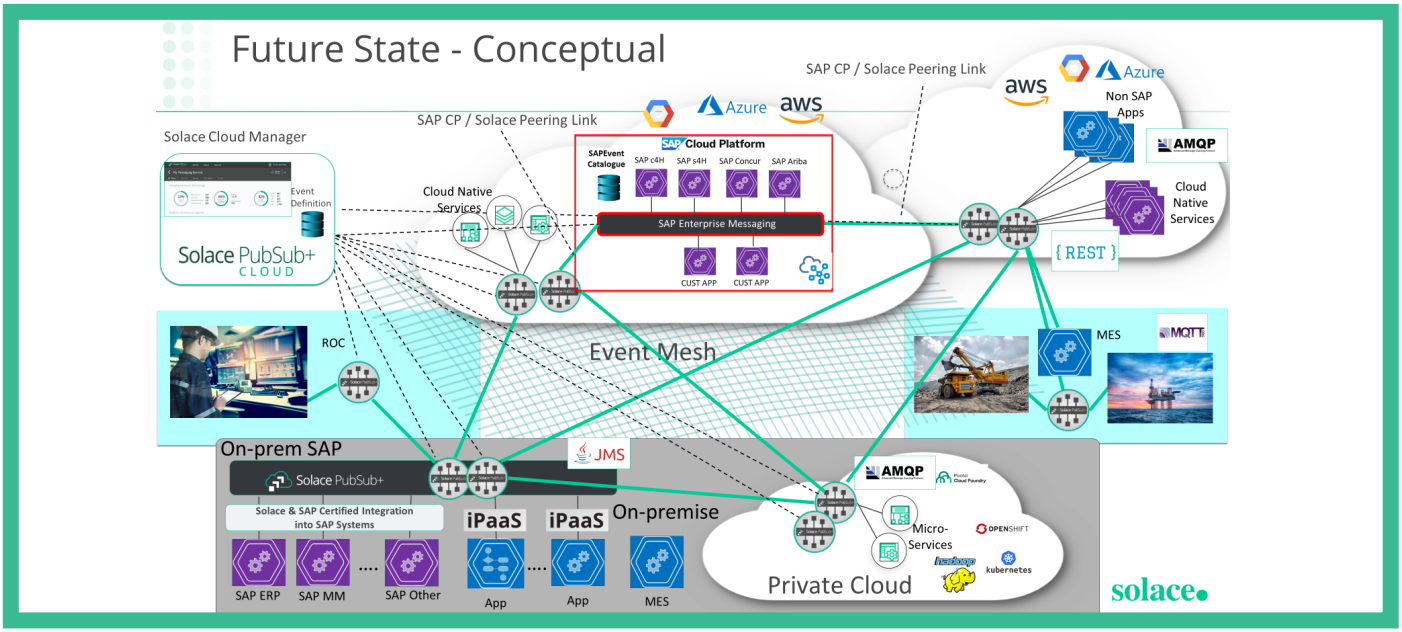


Figure 1 - Future-State Event Mesh

The event mesh is managed via a single-pane-of-glass, using Solace PubSub+ Broker Manager. This allows for the creation, configuration and management of Solace instances irrespective of where they are deployed or whether the instance is PubSub+ Appliance, PubSub+ Software or PubSub+ Cloud. PubSub+ nodes can join and leave the event mesh as required. Public clouds provide a great platform for innovation. However, not all projects will be successful. Agile resource companies need the flexibility to orchestrate new event mesh nodes and tear them down when the work is done. It would take a few minutes to build a public cloud-hosted PubSub+ node. Once provisioned, the node could create the necessary links to the mesh and have access to all the data and events on the mesh, without the need to: create a change request, adapt an interface specification and build, test and deploy new interfaces.

Solace also has an exciting vision of where it is investing to take our event mesh to the next level of strategic capability. We will be pleased to share this vision with your company under an appropriate non-disclosure agreement.

Appendix B - Technical Overview

The overview will attempt to bring together a few more salient detailed capabilities and present the high-level Solace straw-man proposition for an innovation-driven, mining or oil & gas enterprise.

To ensure that technical readers have a consistent level of understanding, some basic concepts will be presented. If the reader is familiar with these concepts, then these sections can be skipped (this refers to section 2.1).

It is generally accepted that the world is moving more towards event-driven architecture (EDA) and event-driven application. However, event and request-driven paradigms are not mutually exclusive, and we don't assume that every application will be event-driven. Real-time processing is critical in many industries and to develop real-time applications demands an event-driven approach.

EDA enables applications to be developed in isolation, which are decoupled. Event-driven applications can be easily scaled elastically, using capabilities offered by modern, orchestrated application platforms and in conjunction with an event broker. In many cases, it is the monitoring of the event broker that triggers application scaling. For example: when an application reads from a non-exclusive queue as input. If the queue depth breeches a threshold, then more application instances can be created to run in parallel.

It should be noted that event notifications are not messages; they are not created with a single consumer in mind. They are published data that can be used by many consuming systems on any platform, in any region.

The event-driven organization should aspire to the mentality of publish once, at event source, and subscribe anywhere. To achieve this requires a consistent, reliable and secure event network.

In the next sections we will talk about Solace PubSub+ and its role in a resource event mesh. And how, by creating an interconnected network of advanced event brokers, resources companies can reap the business benefits of becoming event-driven.

1 Hybrid Integration Platform

Hybrid Integration Platform (HIP) is the term Gartner coined for a set of next-generation integration capabilities. Gartner defines HIP as "a framework of on-premises and cloud-based integration and governance capabilities that enables differently skilled personas to support a wide range of integration use cases."[6]

The aim of HIP is to enable organizations to best navigate the integration challenges of digital transformation. Hybrid Integration relates to types of integrations required, anything from a legacy system of record and public cloud services to remote IoT devices and AI digital twins. These challenges are new and are not satisfied by existing tools and practices.

6 Source: Gartner "Innovation Insight for Hybrid Integration Platform," 15 Oct 2018, Massimo Pezzini

Key components / capabilities of HIP are event-driven application and event brokering. As Gartner states: "Include advanced event brokers when assembling your hybrid integration platform suite to support strategic event-driven solutions in your multiarchitecture application environment."[7]

It can bridge to existing middleware supporting systems of record, liberating the data and events. It deploys onto any platform, meaning the same data and events can be consumed by new application developments on public clouds. It supports multiple open protocols allowing consistent access to events, whatever the application and wherever the location.

Of course, there are other components in the HIP, and these would work in conjunction with the event broker. Many of our customers use PubSub+ as the event infrastructure for an iPaaS such as MuleSoft, Dell Boomi or Axway. The iPaaS and event broker operate in separate layers of the architecture. The event broker would perform message and event management and the iPaaS integration. Key requirements for the event broker are:

- Exchange patterns including publish/subscribe, request/reply, queuing, streaming, fan-out, fan-in;
- Guaranteed and best-effort delivery;
- Open standards such as AMQP, MQTT, REST, JMS and WebSocket;
- Asynchronous API and communication support;
- Sophisticated event routing with wildcards for messaging topics and REST URLs.

In the next sections we will introduce the Solace advanced event broker and the key capabilities that make it the perfect choice for any Hybrid Integration Platform.

2 Solace Advanced Event Broker

The Solace PubSub+ Platform (PubSub+) is the only advanced event broker technology that supports pub/sub, queuing, request/reply, streaming and replay, and that is available as run-anywhere software, purpose-built hardware and a managed service.

PubSub+ was originally developed as a low latency, high throughput messaging appliance and was almost exclusively deployed into capital markets solutions.

Around five years ago Solace took the appliance technology and adapted it to a software version. The software version is delivered using cloud-native technology which enables it to run anywhere.

To help our customers deploy PubSub+ Software we package it into popular machine images and provide accelerators for public cloud deployments and for orchestrated environments such as Kubernetes, Red Hat OpenShift and Pivotal Cloud Foundry.

Most recently, PubSub+ became available as a fully-hosted and managed cloud Messaging as a Service (MaaS) offering – we call this PubSub+ Cloud. PubSub+ supports all message exchange patterns in addition to our proprietary APIs and open APIs.

7 Source: Gartner "Innovation Insight for Event Brokers," 31 July 2018, Yefim Natis, Keith Guttridge, Nick Heudecker, Paul Vincent

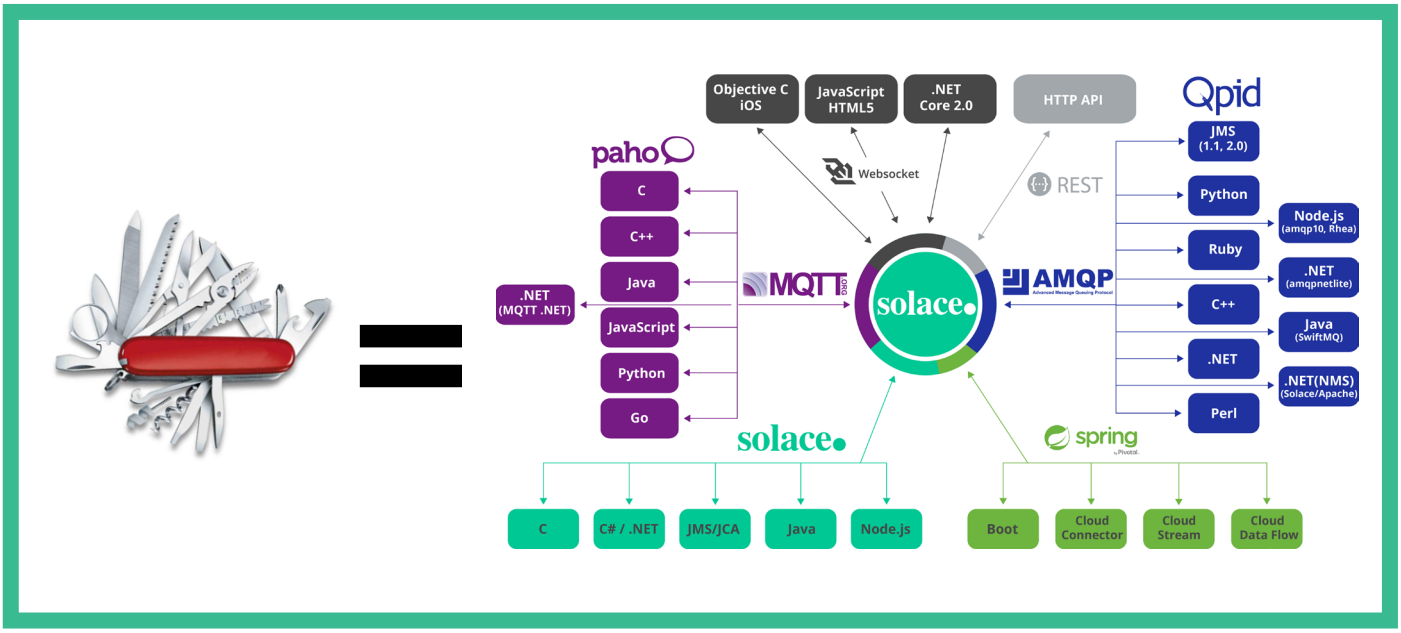


Figure 2 - Solace API Coverage

Solace messaging APIs offer uniform client access to all Solace PubSub+ capabilities and qualities of service, and are available for C, .NET, iOS, Java, JavaScript, JMS and Node.js. Solace also supports popular open protocols like AMQP, JMS, MQTT, REST and WebSocket, and open APIs such as Paho and Qpid. Solace can perform protocol mediation within the broker without the need for client code or broker configuration.

PubSub+ brokers can be deployed as single instances or can be connected to provide a network of interconnected event brokers into what is called an event mesh. Before describing the event mesh in detail it's important to understand the concepts that underpin the event mesh.

2.1 Publish and Subscribe

Publish and Subscribe or Pub/Sub is an exchange pattern supported by PubSub+ brokers. In Pub/Sub there are three main actors:

- Producer
- Consumer
- Topic

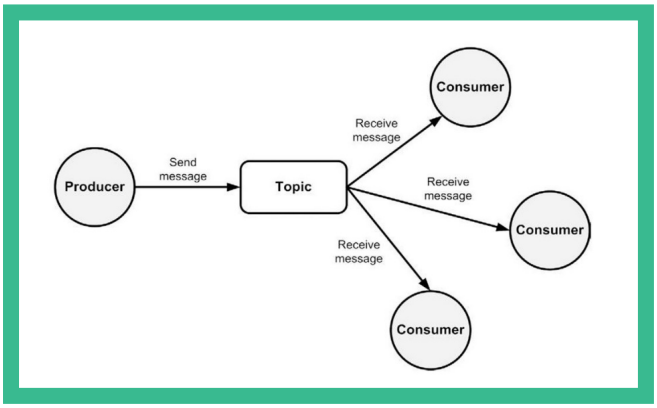


Figure 3 - Publish and Subscribe Exchange

Pub/Sub differs from point-to-point messaging in that producers (publishers) and consumers (subscribers) are logically decoupled. Producers publish topics (more on these in the next section) into the broker with no knowledge of the subscribers.

On receipt of a topic publication, the broker will match it against any interested parties (subscriber) and will forward the message to any and all interested parties. Topics are dynamic and require no setup. Similarly, consumer applications can (un)subscribe to topics dynamically, without the need to change producer application code or the broker configuration.

2.2 Solace Topics in PubSub+

Topics in PubSub+ are defined by the producer and published as part of the message. Figure 4 shows the structure of a published message. The topic is a component of the header. The power of the topic comes from careful design of the topic structure. A modelling approach is required to design a hierarchical structure which can be used to efficiently group topics by subscribing applications. There is no need to create the hierarchy in PubSub+, but the publishing applications should follow the convention.

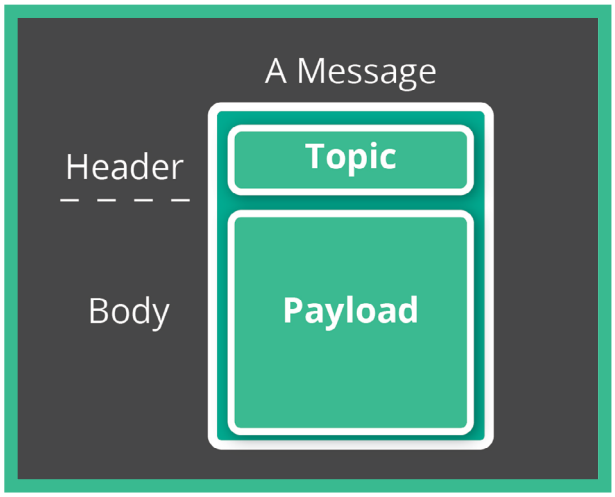


Figure 4 - Topic Structure in PubSub+

The structure of a topic hierarchy is shown below (Figure 5). In this case, it is a vehicle tracking topic (possibly published by an IoT device). You can see that the topic contains information that is extracted from, or known about, the message content.

NB: Topic routing in Solace is essentially content routing without the overhead of having to examine each message payload.

Consumers also need to be aware of the topic hierarchy to enable them to efficiently subscribe to the topics of interest.

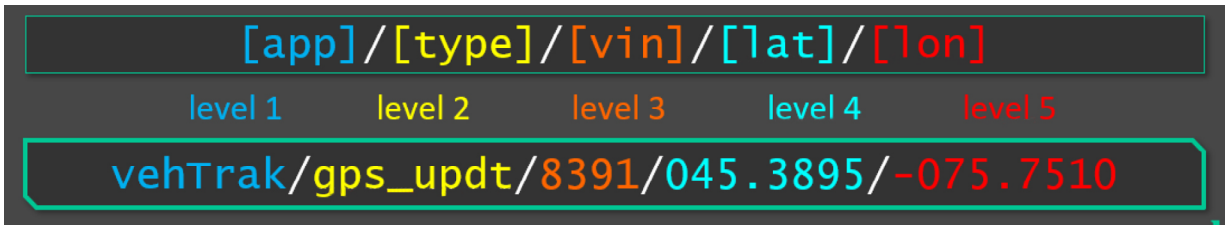


Figure 5 - Solace Topic Hierarchy

The importance of the topic hierarchy becomes evident when you adopt the role of the consumer (subscriber). Because the Solace topic is hierarchical, subscribers can request topics via wildcards. Solace supports the following wildcards:

- Single-level * – this can be used with a prefix
- Multi-level >
- Corresponds to MQTT wildcards: "+" and "#"

Some examples where wildcards are used:

Example 1: Consumer subscribes to all events for vehicle VIN '8391'.

```
vehTrak/*/8391/>
```

Example 2: Consumer subscribes to gps_updt events for all vehicles.

```
vehTrak/gps_updt/>
```

Example 3: Consumer subscribes to gps_updt events located between 45.3°N-45.4°N and 75.7°W-75.8°W.

```
vehTrak/gps_updt/*/045.3*/-075.7*
```

2.3 Dynamic Message Routing

Dynamic Message Routing (DMR) is the technology in PubSub+ that implements the event mesh. DMR allows individual brokers to connect and form the network of event brokers. Links between brokers are created, and a cluster is formed. Once the cluster is established routing rules are shared across the brokers, in the cluster, and are updated dynamically.

Clients can now connect to nodes in the cluster. If a producer publishes to a node and there is a remote subscriber, DMR will route only the messages that satisfy the subscription to the remote node. DMR ensures the most efficient routing of messages whilst still assuring the message quality of service.

DMR allows for different topologies to be implemented depending on the requirements. Links between nodes can be uni or bi-directional.

3 Event Mesh

The event mesh is the concept implemented by DMR. Below is a slightly more succinct description of an event mesh than the one offered in Section 2:

"An event mesh is an architectural layer that routes events from producers to consumers in a flexible, reliable and governed manner, no matter where your apps are deployed."

The need for an event mesh becomes apparent when we examine a typical "current state" IT landscape.

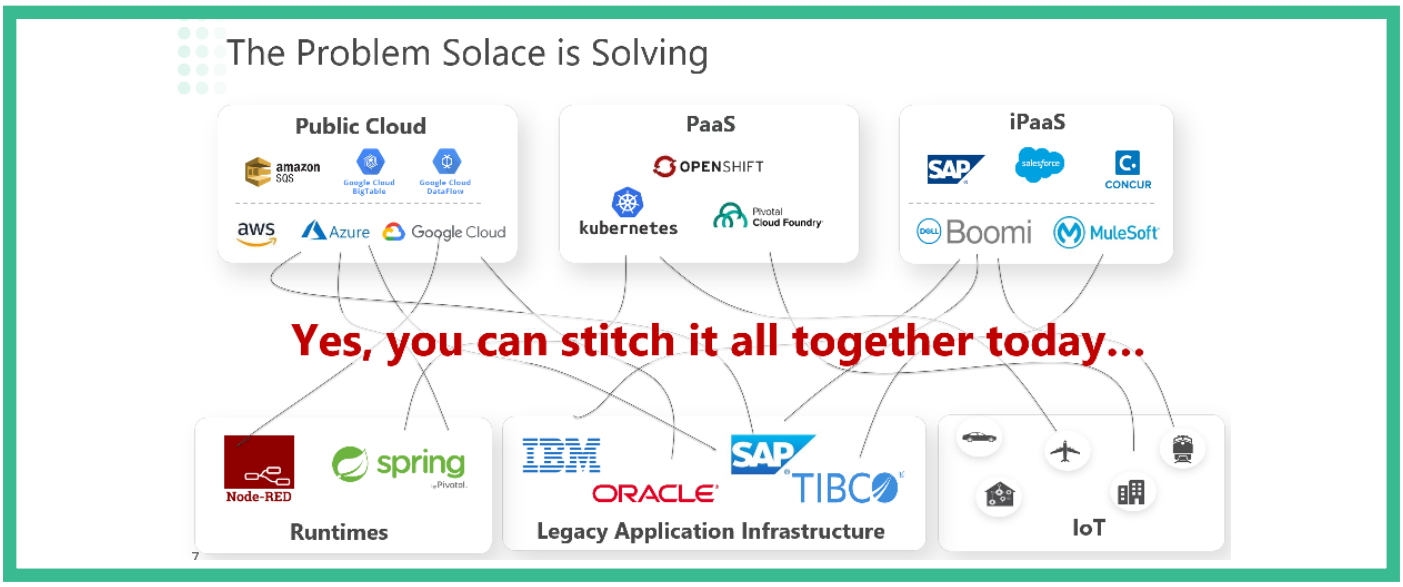
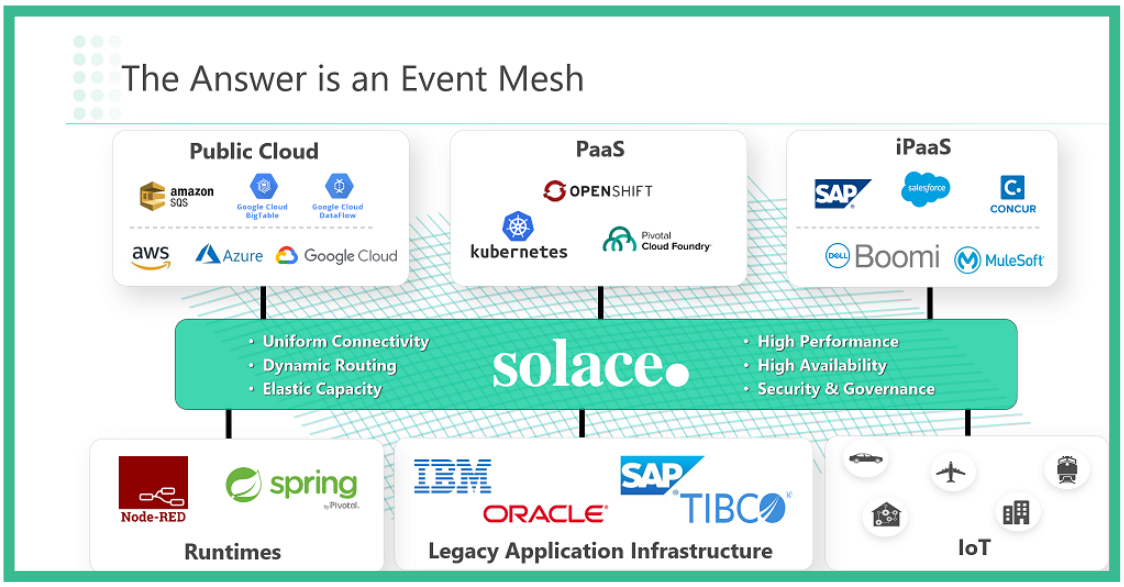


Figure 6 - Current State Integration

The current state involves a lot of point-to-point integration. Services are orchestrated using systems that become bottlenecks to efficient processing and are impossible to scale. Protocol mediations are performed many times using computationally expensive processing. However, the data and events in these systems are critical to the business. To take advantage of opportunities like cloud, digital services, and IoT the data in these systems must be liberated.

Moving to the cloud will be problematic. Adoption of proprietary cloud-native services can mean lock-in. As well, moving data in and out of public clouds can be expensive and needs to be as efficient as possible. Any strategy that involves the cloud must consider hybrid and multi-cloud.



Solace PubSub+ has been developed to operate on any platform. Deployments of Solace can be managed using orchestration frameworks and cloud-native infrastructure-as-code technology. All versions of Solace PubSub+ can collaborate in the event mesh, meaning that edge brokers at the mine or pipeline site can publish data in MQTT that is subscribed by a business application or an ML application anywhere on the mesh. The data is delivered with the desired quality of service.

The event mesh is dynamic, and nodes can be added and removed from the cluster over time. There will be many occasions where an event stream is required on a temporary basis. Using this technology, the resources enterprise could provision a cloud-hosted PubSub+ node, have this new node connect to the mesh, and then subscribe to the data required, and *only* that data. This could all be provisioned via CloudFormation (as an example) without any manual set up. The real power though is that this is done without impacting the producer or any existing subscribers. Once the work is complete the CloudFormation stack can be deleted.

In summary, we believe an event mesh should be a key component of a resource company's future-state IT architecture. And we believe we have the best technology to realize this architectural goal.

3.1 Event Mesh On-Ramps

On-ramps is a term we use to access the mesh. All applications connect to the event mesh as clients. Any client accessing the mesh would first need to authenticate and then would need the authorization necessary to perform the operation being requested.

Some examples of accessing the event mesh are provided:

- IoT devices would connect to the mesh across the available network (LTE, LoRa) using MQTT or REST.
- In the case of microservices development, it is likely that the developer directly uses the API (Solace or Open API), or would use a supported framework such as Spring Cloud Stream, Spring Boot, PCF, etc.
- Solace also offers capability to connect to the event mesh from other middleware solutions or database products by using connectors. Some of the connectors can be provided by Solace under open source arrangements or via validated partners. More details on available connectors are provided in the capability sections.
- In each case, events on the event mesh are handled consistently. An AMQP client in a business application on-premises can consume a machinery event published from a mine, drill rig or pipeline over MQTT, via the event mesh, without the need for any protocol mediation. Furthermore, the same event can get routed to many applications subscribing to that event.

Addendum - Getting Started with Solace PubSub+

This section provides some guidance and links for those wishing to further explore event-driven applications or contemplating building a Solace-enabled event mesh.

1. Where to start

Solace offers online training courses via Udemy that are a great place to start.
udemy.com/fundamentals-of-solace-administration
udemy.com/fundamentals-of-solace-development

2. Where to get the software

The easiest way to start developing quickly is via the Solace PubSub+ Cloud portal. It takes seconds to create an account and all the information regarding APIs and tutorials are presented in the portal.
solace.com/cloud/

For the more adventurous, you can download the Docker image or one of our machine images. Our PubSub+ Standard edition is completely free.
solace.com/downloads/

3. I want more

Solace provides tutorials for APIs and popular use cases here.
docs.solace.com/Developer-Tutorials/Developer-Tutorials.htm

And of course, feel free to explore our GitHub repositories.
github.com/SolaceProducts
github.com/SolaceLabs
github.com/solacesamples

4. I still need further technical help

Please feel free to contact:

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