New ICT infrastructure and reference architecture to support Operations in future PI Logistics NETworks

D2.21 ICONET PI PoC Integration Platform – Final Version

Document Summary Information

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Responsible Author	Kieran Flynn (IBM)		
Contributions from	John Farren (IBM), CLMS, NGS		

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Glossary of terms and abbreviations used

Abbreviation / Term	Description
API	Application Program Interface
AS	Autonomous System
AWS	Amazon Web Services
DBaaS	Database as a Service
Dev-ops	Development and Operations
DNS	Domain Name System
DoA	Description of Action
DoW	Description of Work
EC2	Elastic Compute 2 {Amazon Service}
ELK	Elasticsearch Logstash Kibana
ESB	Enterprise Service Bus
GA	Grant Agreement
GUI	Graphical User Interface
IaaS	Infrastructure as a Service
IoT	Internet of Things
LAN	Local Area Network
LL	Living Lab
NFV	Network Function Virtualisation
NOLI	New Open Logistics Interconnection
OLI	Open Logistics Interconnection
OSI	Open Systems Interconnection
P&G	Proctor & Gamble
PaaS	Platform as a Service
PI	Physical Internet
PoA	Port of Antwerp
PoC	Proof of Concept
QoS	Quality of Service
R&D	Research & Development
RAM	Random Access Memory

RON	Resilient Overlay Node
SB	StockBooking
SCN	Scenario
SDN	Software Defined Networking
SLA	Service Level Agreement
SoTA	State of the Art
T&L	Transport & Logistics
TCP/IP	Transmission Control Protocol/Internet Protocol
vCPU	Virtual Central Processing Unit
VLAN	Virtual Local Area Network
VXLAN	Virtual Extensible Local Area Network
WP	Work Package

1 Executive Summary

IBM addressed the majority of the goals for the PoC Integration during work documented in Deliverable D2.20. This involved the creation and configuration of the virtual networks, infrastructure, deployment of PI Services and both service-to-service integration and service-to-simulation integration. In this document IBM has furthered the achievements of D2.20 by addressing the remaining goals and then enhancing the flexibility, security and robustness of the PI Service networks, communication, node-to-node communication and PI Service deployments by ensuring they are cost effective and valid in real world scenarios. The defined approach allows PI Service developers to focus on PI related functionality for logistics operations and offloads non-functional requirements (security, config etc.) to the PaaS services and dev-ops personnel. The use of PaaS systems allowed IBM to extend the scope of work beyond the DoA requirements and ensure the PoC Integration Environment and the PI Services residing within adopted real world dev-ops based production strategies and technologies to ensure PI Service deployments would be instant, automated, secure, robust etc.

IBM identified machine learning based PI Services as having a unique set of challenges and requirements and also likely to play an increasingly large role in the PI Service suite. Strategies and technologies were adapted to address the needs of ML Services while ensuring they were compatible with the existing frameworks supporting standard PI Services. Strategies around data acquisition and quality, ensuring machine learning based services are recent and up to date, that new models are validated before deployed and paradigms that see analytics outside the cloud, at the edge of PI networks.

IBM identified key emerging trends in cloud technology and deployments that are likely to both mirror trends in PI Service deployments but also impact them too. IBM researched leading technologies striving to address these trends and applied them to the existing PoC environment created in Version 2, while expanding beyond that to a likely future PI scenario that relies on multiple cloud vendors in combination with local, legacy and private cloud and software technologies used by logistics organisations. These new concepts of multi-cloud and hybrid-cloud will expand the reach of the cloud beyond the datacentre and out to edge and low power devices in the fog. As IoT becomes more prevalent in the transport and logistics sector, the ability for the PI to leverage these new technologies while adapting to future trends is critical and the research in this document lays out recommendations to take advantage of new cloud and fog computing trends. This allows for PI Services to be deployed and managed in a distributed yet orchestrated manner across heterogenous device types. All of which looks to the future and aids in increasing the adoption potential, and subsequently increasing the future disruptive potential, of PI Services.

This deliverable ends with a visualised blueprint containing all major components, services, systems and ICONET technical assets that were created, configured, deployed and developed as part of all three PoC Integration Platform deliverables. This ties together the work across all three documents and presents the work in a unified manner.

The work done and documented in this deliverable and the previous deliverable versions show that the PoC Integration Environment successfully met the requirements as laid out by the DoA, successfully met the requirements of the ICONET WP2 and Living Lab participants, and in fact went beyond the initial DoA to adapt to future requirements such as security, integration and modern deployments. It shows that a design methodology was adopted to ensure that the cloud and edge computing paradigm requirements of the future were forefront in design considerations.

2 Introduction

This deliverable describes the methodology, design decisions and work done under **Task 2.7 PoC Integration Platform (**previously known as **Control and Management Platform).** The PoC Integration Platform task and associated work has two main goals. The first is to drive the integration of these assets across a number of scenarios. The second is to support and facilitate the development and deployment of PI Services and other technical assets required to further research in the PI domain. The substantive work towards these goals were achieved and described in D.20, the intermediate version of this deliverable. The research and effort for this deliverable focused on how the approaches already taken were refined and improved upon and how they can be applied and adapted for the PI vision with regards to current and emerging technical trends.

2.1 Deliverable Overview

- **Executive Summary –** An overview of this document's contents
- **Introduction –** Introducing the context of this document to the previous version and the DoA requirements
- **Integration Strategies & Approaches –** Discussing the different connectivity scenarios and approaches as they were applied to the PoC integration platform and PI Nodes
- **Deployment –** Discussing the technologies and approaches used for a modern, production level strategy deployment framework
- **Machine Learning Deployments –** Discussing the unique challenges and requirements of machine learning based PI Services and the approaches used to address them and combine them with existing PI Services management frameworks.
- **Future Trends in PI Service Deployment Models –** Discussing how emerging trends in cloud deployments will apply to the PI in the near future, and how the PoC Integration created for ICONET is adapted for modern hybrid/multi cloud environments of the future, discussing specific technologies and approaches.
- **Conclusion –** Overview of work and lessons learned

2.2 Goals of the PoC Integration Environment Task & Deliverable

As discussed in Version 1 and Version 2 of this deliverable, the goals of the PoC Integration Platform are to provide a flexible, cloud enabled digital workbench which will facilitate the technical research actions in the project. The platform provides a secure enclave where PI Services can be deployed, developed, tested and integrated. As the development moves to the final stages, the focus shifts more to integration actions and ensuring that the living lab scenarios are digitally represented within the PoC environment. This spans from ensuring access to the relevant datasets to multiple deployments of single services as each has been configured for a particular scenario.

With these core goals met, IBM elected to expand the scope of the requirements and has investigated the potential usage paradigms from a cloud and deployment perspective that will likely exist by the time the PI becomes a global reality. Deployment paradigms based on hybrid cloud, multi cloud, edge and fog computing were considered within the PI context to provide a roadmap to potential real-world implementations.

2.3 Summary of Version 2 (D2.20) and Overview of this Deliverable

The intermediate (2nd) version of this deliverable (D2.20) discussed in detail the following topics

- The Integration Environment Architecture
- Dataflow and interconnectivity scenarios for the PI Services
- The goals and objectives of the PoC Environment

- The Infrastructure and Network Topology of the PoC Environment along with the deployment and configuration of compute and storage systems
- The strategies, tools and systems used to support the simulation systems
- PI Services Deployment & Integrations

The work undertaken for deliverable D2.20 addressed much of the goals and requirements of the associated tasks. The approach taken for this deliverable was to enhance the existing infrastructure and frameworks in terms of features – both functional and non-functional and to expand the scope of the research in a means which would further the PI. This was done by integrating dev-ops strategies and approaches to PI Service deployment, providing specific technological approaches for machine learning based PI Services and by addressing secure connectivity from a cloud engineering perspective and allowing PI Service developers to focus on core PI Service functionality. In addition, future trends in cloud service deployments were researched and emerging trends were applied to known PI scenarios. Emerging technologies addressing these trends were evaluated in respect of the existing PoC environment and recommendations for future PI networks were made.

2.4 Leveraging Platform-as-a-Service

Platform-as-a-Service (PaaS) is specifically addressed in the ICONET DoW as the preferred approach for engaging cloud services in the ICONET project. As shown in Figure 1, there are three major paradigms – SaaS (Software-as-a-Service), PaaS (Platform-as-a-Service) and IaaS (Infrastructure-as-a-Service). SaaS is a user facing model, example of which are gmail, slack, google docs etc. PaaS is used primarily by software developers or dev-ops to enhance or support the application they wish to present to users. IaaS is primarily used by administrators and is the underlying compute and similar resources that support the platform and applications above, which is ultimately powered by the actual bare metal hardware of servers, switches, hard disks etc.

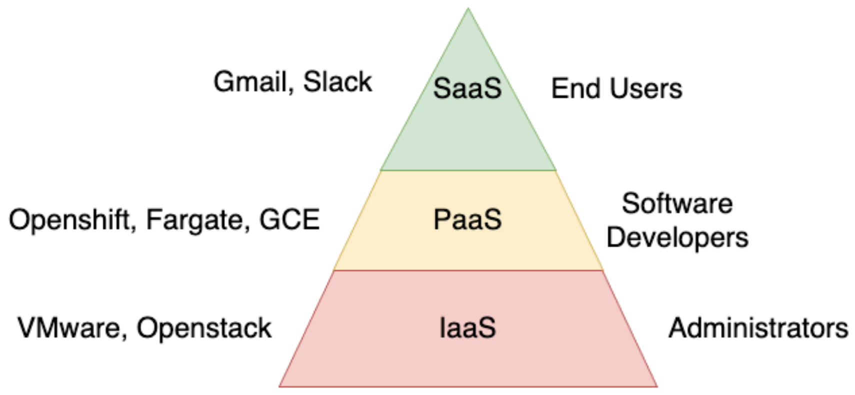


Figure 1 - PaaS, SaaS & IaaS

There are many different systems that can fall under the PaaS umbrella. These could be computed or similar systems to support applications running in the cloud such as GCE (Google Cloud Engine), Kubernetes, Red Hat Openshift or AWS Fargate but can also encompass non-functional frameworks such as security systems, firewalls, load balancers, SDN (Software Defined Networking). Anything that a software developer or dev-ops engineer can engage as a pre-existing service without having to develop, install or construct themselves can be considered a PaaS service.

The benefits of PaaS to ICONET, and why it was specified in the DoW as the approach to take, is that less time and effort needs to be spent on developing and building non-functional systems. The bulk of the effort can be instead focussed on the core task at hand – namely the research and development of the PI Services and systems and the integration of those systems in a manner to address the Living Labs requirements. In this project Amazon Web Services (AWS) was chosen as the cloud vendor (in a selection process that also included Google Cloud Engine and IBM Cloud as candidates). AWS was chosen as it had a particularly rich catalogue of PaaS options, some specifically identified as useful for ICONET such as Lambda and the API gateway. ICONET also engaged the use of Virtual Private Clouds, Software Defined Network Infrastructure, Elastic IP Addresses, Elastic Load balancers, Elastic Container Registries, Elastic Container Services, Identity and Access Management, Deployment Pipelines and more services beyond. All of these services have commercial or open source alternatives, but a significant amount of time and effort was saved by choosing PaaS alternatives, and at a very low financial cost. This allowed ICONET to hit the ground running so to speak in terms of focusing efforts immediately and directly at the core high value development and research objectives of the project.

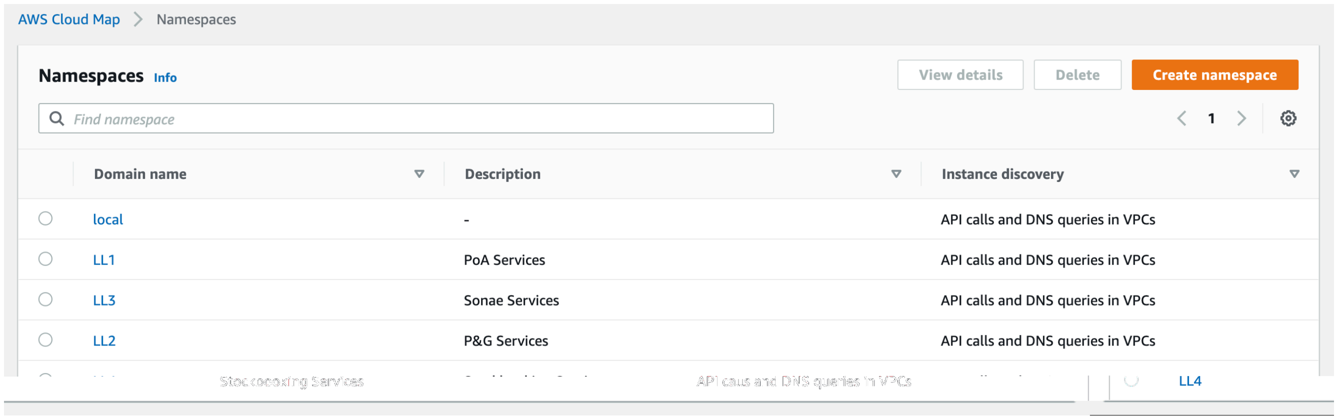
IBM has taken initial steps to ensure the viability of the PI Services in alternative cloud models. This is discussed in more detail in the **Future Trends in PI Service Deployment Models** section.

3 Integration Strategies & Approaches

In version 2 of this deliverable the pilot integration of the optimisation service and the simulation service were discussed. The core mechanic of the integration is the ability for the Anylogic simulation service to make REST API calls to the optimisation service.

3.1 Service Discovery

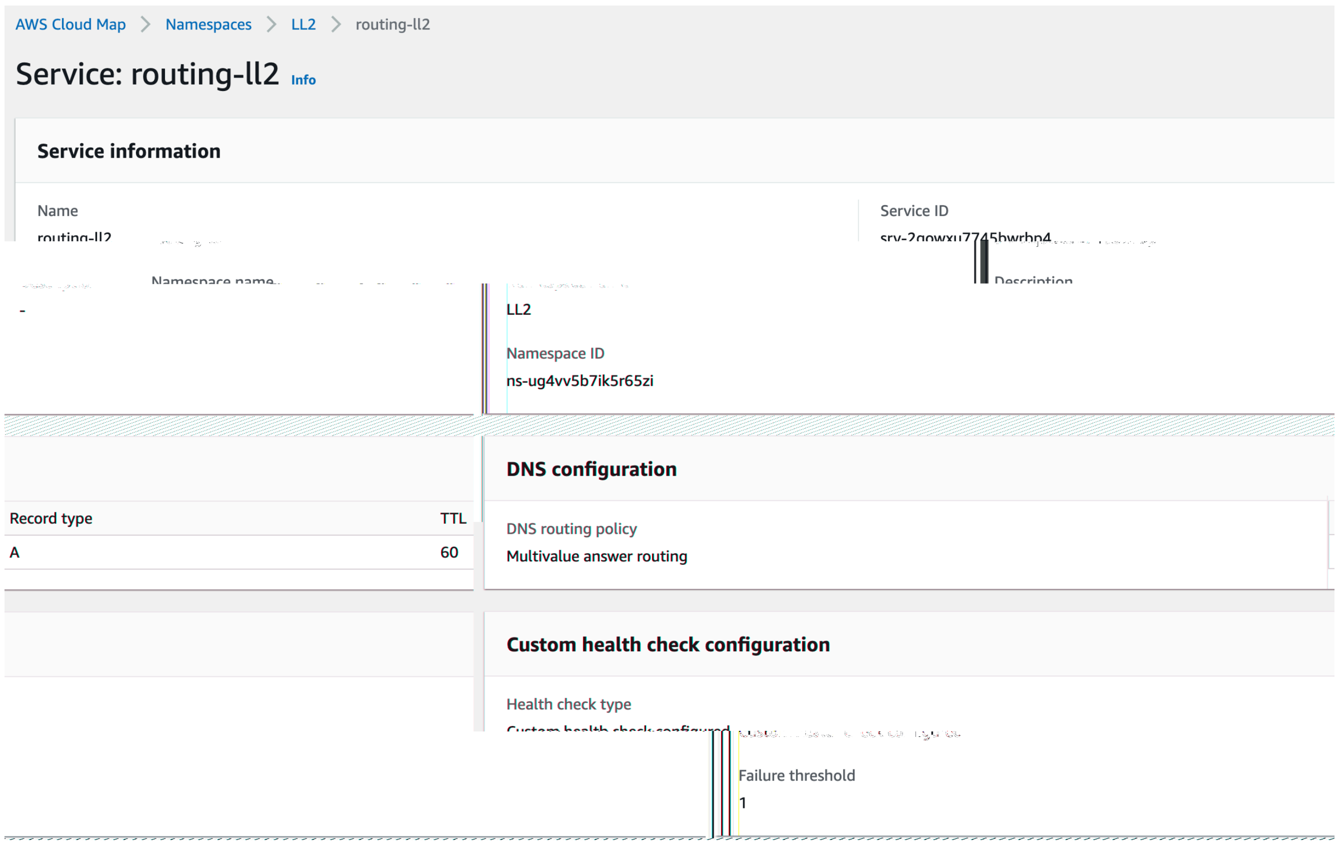
At this stage of ICONET, all services and associated APIs are now complete and published to the ECR (Elastic Container Registry) where multiple versions and iterations of each service are stored as docker image templates. Each image has been deployed and a number of services have been deployed multiple times to allow the integration and testing across various living lab scenarios. In addition, services are no longer deployed as isolated entities, as WP2 explores and configures the interdependencies of certain services on other services. For example, the routing service will make requests to the networking service and the shipping service makes requests to almost all other services. As individual services are redeployed (after an update or a bugfix) their local IP address may change. The results of this new stage of development and integration is a larger and ever-changing number of services, bound to changing IP addresses with different purposes, integrations and configurations. It is impractical to manage the publication and communication of these variations manually and in a real word environment this process needs to be managed programmatically. Therefore, for the PoC environment, Service Discovery is enabled for all services. Service Discovery is facilitated by DNS (Domain Name Servers) and configured by an internal AWS service called Cloud Map.



Domain name	Description	Instance discovery
local	-	API calls and DNS queries in VPCs
LL1	PoA Services	API calls and DNS queries in VPCs
LL3	Sonae Services	API calls and DNS queries in VPCs
LL2	P&G Services	API calls and DNS queries in VPCs
LL4	Stockcooking Services	API calls and DNS queries in VPCs

Figure 2 - AWS Cloud Map Namespaces

As shown in *Figure 2*, Cloud Map allows for the creation of namespaces and service names. A namespace is simply a designated collection of entries under a common category. In WP2 there are five namespaces, one for each living lab and an additional namespace for more broad integration and testing deployments. Within each namespace any number of service names are defined and then associated with a given service. For example, the namespace for Living Lab 2 has a service within it for routing simply called “routing”. This service is associated with the actual deployed routing service which is specifically deployed for Living Lab 2 which is labelled as “ll2-routing”. When the developers of another application wish to interact with this specific service, they need only point the service at the “routing.ll2” endpoint and the DNS servers managed by AWS will point requests at the IP address of the “ll2-routing” service.



AWS Cloud Map > Namespaces > LL2 > routing-ll2

Service: routing-ll2 Info

Service information

Name
routing-ll2

Service ID
srv-2qowxu7745bwrbp4

Namespace name
LL2

Description
-

Namespace ID
ns-ug4vv5b7ik5r65zi

DNS configuration

DNS routing policy
Multivalue answer routing

Record type	TTL
A	60

Custom health check configuration

Health check type
Custom health check configured

Failure threshold
1

Figure 3 - LL2 Routing Service DNS Entry

This process only works however if the developers already know the endpoint and know what that specific function the service at that endpoint has or does. In order to provide a programmatical way to acquire this information it is possible to associate any number of “tags” to a given endpoint. The tags can describe relevant information about the service and can include, but are not limited to:

- Port number the service is listening on
- Version number of the service
- Living Lab the service is operating for
- Dataset the service is using.

The tags are managed by Cloud Map and a developer can access these tags as well as request full listings of all namespaces and all services within specific namespaces by making API requests against the Cloud Map service itself. While Cloud Map is a proprietary service offered by AWS all major cloud vendors will have similar systems for managing Service Discovery or indeed 3rd party implementation can be used. Having developers tailor each service to be able to interact with each particular implementation is not practical so it is desirable for a common interface to be designed. In the case of the ICONET PoC, a simple API service can be developed that relays the information from Cloud Map to the service. This still needs to be updated to match the given deployment scenario, but it is a single point of configuration change, as opposed to multiple points of change that would be needed without the API relay.

3.2 Service Mesh

The next evolution of Service Discovery is the Service Mesh. This is a concept that allows developers and administrators to see and understand the relationship between all services and view them as a single entity in terms of logs, metrics, connectivity, troubleshooting etc. Of particular relevance to the ICONET project is the ability to divide requests to a single service into multiple lanes and send those lanes to specific service instances.

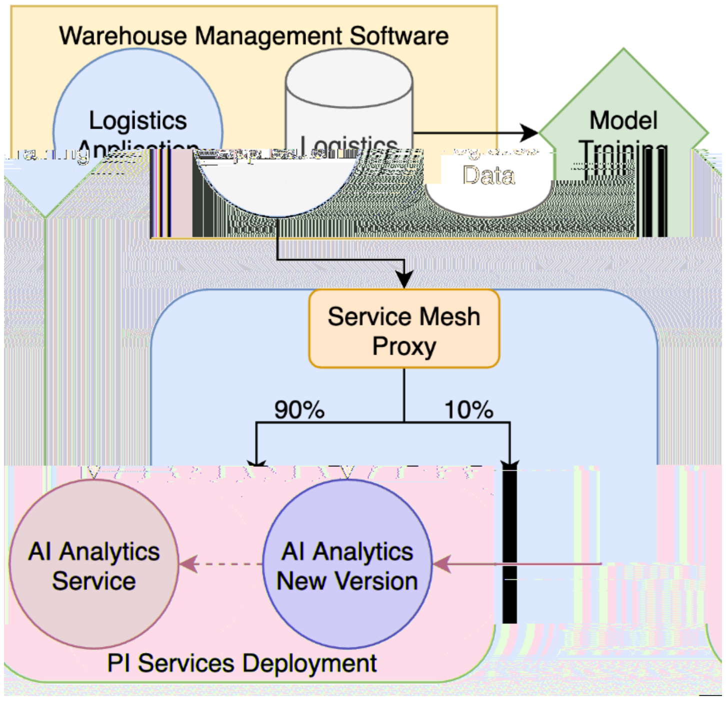


Figure 4 - Service Mesh Flexible Routing

In Figure 4 we see an example. In this scenario a warehouse management software system is using a machine learning powered analytics service to help optimize operations within the warehouse. Data regarding the warehouse operations is stored by the management software and is used to train new machine learning models based on recent activity ensuring the analytics and predictions are up to date and as accurate as possible. New models are deployed on a regular schedule. The logistics application then makes requests directly to the analytics service. However, when a new model is ready to be deployed it is not good practice to push it to a live deployment without first undergoing a verification phase. The use of a service mesh allows a single endpoint proxy that the logistics application will interface with. The application is not aware of nor need it be aware of any changes that occur behind the proxy. The proxy is configured to route a percentage of traffic to the new model where it can be verified while the majority of traffic is routed to the current model. Once confirmation is received the new model is performing in line with the old model, the new model can be configured to accept 100% of the traffic with no interruption to service.

In the ICONET PoC AWS provides a mesh service known as App Mesh as it allows full integration with existing AWS services. All major cloud vendors offer comparable services and in case of an on-prem or self-managed cloud deployments and these approaches can be easily replicated across any vendor or using open source private cloud approaches.

3.3 External Integration & Access Scenarios

The ICONET PoC Environment has three major external integration points:

- Data acquisition from non-PI legacy logistics systems (such as a warehouse activity database)
- PI Service access and use by non-PI logistics systems (such as warehouse management software)
- Simulation access for interested parties to view, use and evaluate simulations.

In addition, PI Service developers access the PI services and simulation services via the secure VPN server. In Figure 5 below we can see a visual representation of these integration points.

- Point A (top left) represents Anylogic users accessing the ICONET PoC environment. This is unique to the ICONET PoC and allows industry stakeholders to access, use and trial the simulations that utilize the PI Services and demonstrate the KPIs against which they will be evaluated.
- Point B (middle left) represents a legacy logistics service utilizing and communicating with a PI Service
- Point C (middle right) represents an ICONET WP2 PI Service developer accessing the PoC environment via secure VPN
- Point D (bottom left) represents a legacy logistics system passing info and datasets to datastores used by the PI Services

These 4 scenarios are discussed in more detail in the following sections.

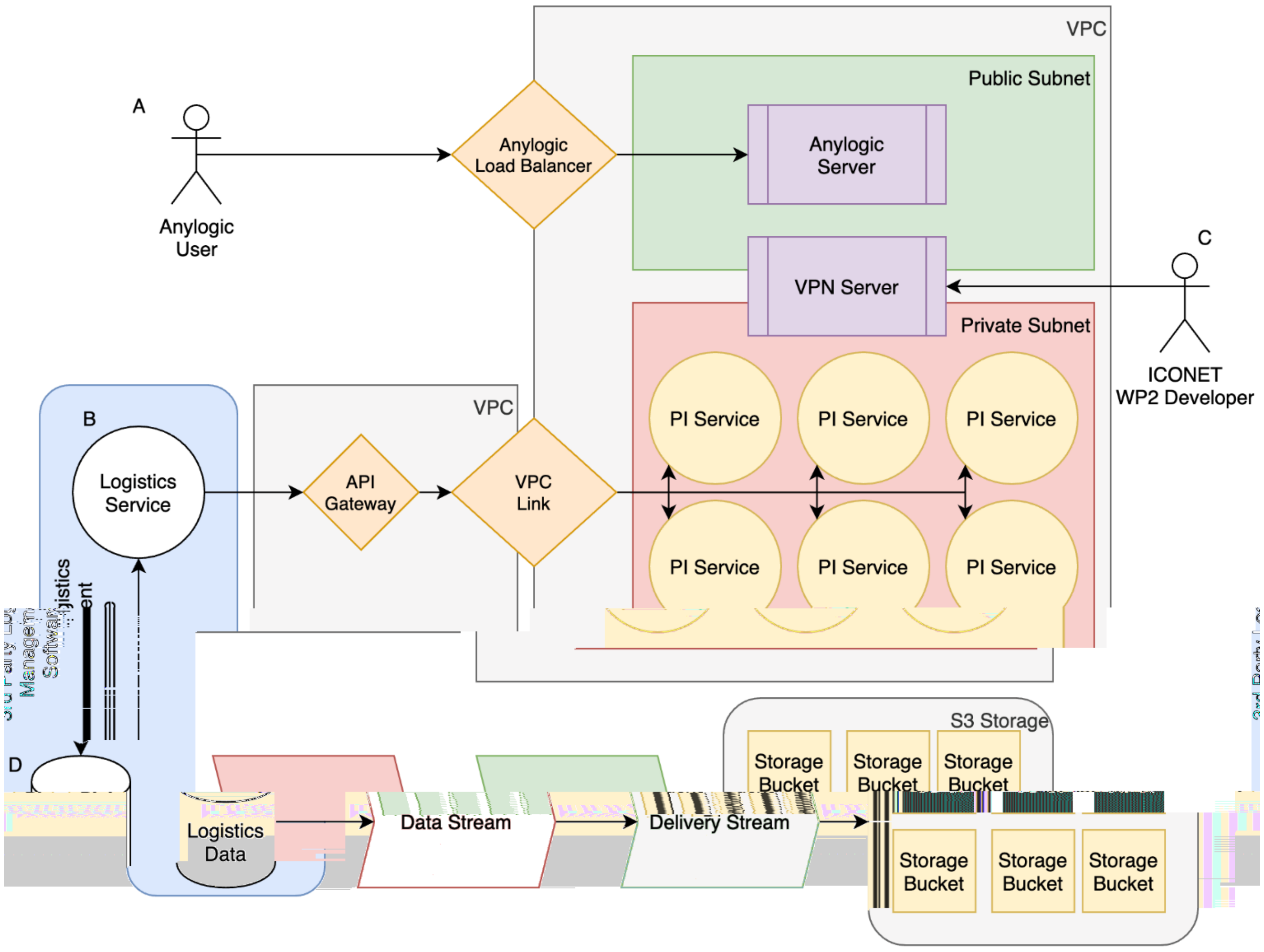


Figure 5 - External Integrations

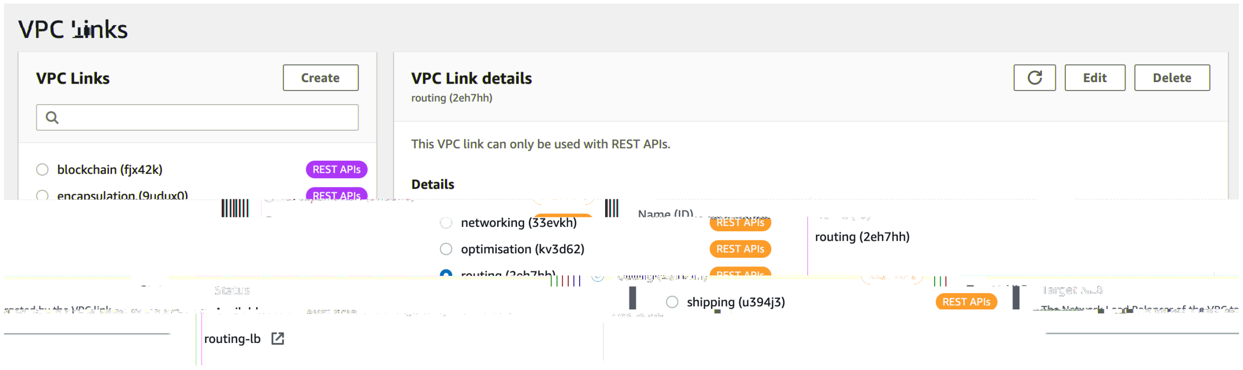
3.3.1 Simulation Access (A)

The simulation service is deployed on a high resource virtual machine running Ubuntu Linux. The simulation service is actually comprised of a large number of distinct microservices, each communicating with each other. The internal connectivity requirements have been discussed in Version 2 of this deliverable and can be summarised as simply requiring the ability to access the various PI Services that are deployed in the PoC. However, in addition to this there are two further connectivity scenarios that are relevant in the final stages of the project. The Anylogic Simulation allows for users to create (or alter) simulations on the client on a local machine or laptop and then push these new simulation scenarios to the cloud. Users can then use the Anylogic user interface to observe the results of the simulations as they run. Initial requirements were that Itainnova had the ability to do these tasks as they are the core simulation model designers and simulation experts of the project. They did this by connecting to the secure VPN (as discussed in Version 2). However, at this stage ICONET looks to make these offerings available to a wider audience. However, allowing external users to connect via the VPN is neither practical or secure as it is desirable to prevent public access to the back-end services and systems. To allow users to access the Anylogic systems an Internet facing load balancer is configured. This is an ELB (Elastic Load Balancer) that is software-based load balancer available from AWS. This was configured as an Application Load Balancer which means traffic can be filtered or blocked based on the traffic type (HTTP, HTTPS, SSH, etc.). ELB is a distributed system backed by AWS, so it has resistance to some common attacks and also distributes connectivity across multiple geographical zones. This means that in the event of a catastrophic failure at a specific datacentre, the service will remain live and available. The ELB provides a static public address that users can use to connect to the Anylogic UI. Anylogic provides its own user management system so there is no need to configure authentication, users, passwords, access control lists etc. The load balancer ensures that requests made via HTTP/S are forwarded to the Anylogic services, and all other requests are denied as intrusions. The load balancer also performs period health checks against the Anylogic service, a simple request to ensure the service is still responsive. For the PoC a failed health check will generate a notification to the administrator but for production level environments automated mitigating action can be configured.

3.3.2 PI Service Access (B)

Although this is a research project, it is good design practise to consider security and data protection at the outset of a development process. All the PI Services are developed in a microservices ecosystem where each service is supplied as a docker image. Each image has implemented the core functionality of that service and has not implemented any schema’s related to networking, security or data protection. There are two reasons for this. The first is that this allows developers to focus on the core solution they are building and doesn’t require expertise in other areas or time spent developing in other areas. The second is that by ensuring only the core functionality is addressed the PI Services are universally adaptable to an external solution that address the non-functional requirements.

Focussing on security and authorisation, we can see in *Figure 5* above that external systems will access the PI services through an API gateway. In the case of the ICONET PoC the API gateway is a service provided by AWS but there are many off the shelf tools that can be customised. The API gateway is essentially the “first point of contact” with an API from external systems. The API Gateway resides in its own private network, which is public internet facing, and appropriately firewalled and protected for this reason. The API gateway accepts incoming requests and based on the specific parameters is routed through the VPC link to the front facing load balancer of a given PI Service. The VPC link is a dedicated network route that connects the private VPC where PI Services reside to the public facing VPC where the API Gateway is but can only be used by the API Gateway itself. *Figure 6* shows some of the VPC links used in the ICONET PoC and the Routing VPC Link points at the Routing Load balancer.



VPC Links

- blockchain (fjx42k) REST APIs
- encapsulation (9udux0) REST APIs
- networking (33evkh) REST APIs
- optimisation (kv3d62) REST APIs
- routing (2eh7hh) REST APIs
- shipping (u394j3) REST APIs

VPC Link details

routing (2eh7hh)

This VPC link can only be used with REST APIs.

Name (ID)	routing (2eh7hh)
Target NLB	routing-lb

Figure 6 - VPC links to Service Load Balancers

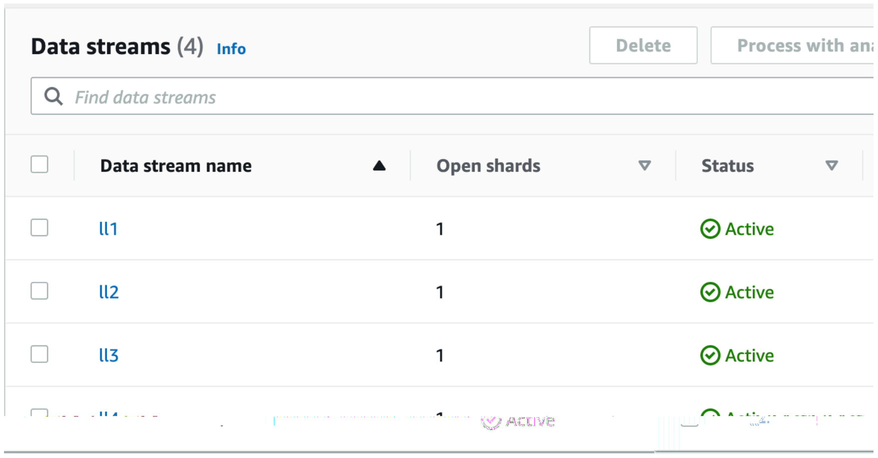
There are many possible actions the API gateway can perform before but the main focus in this implementation is that the API gateway is configured with an authoriser. The authoriser can be configured to work with existing identity management systems to allow only requests that contain authorised tokens and secret keys to access a specific PI Service. This allows authorisation and access to all PI Services to be managed in a centralised manner while offloading this responsibility away from the PI Service developers.

3.3.3 Developer Access (C)

This integration point is for development and administrator access only. By design only interfaces that require external access are made accessible on public networks. There are a number of additional interfaces and components that are in the PoC environment that are not accessible publicly for security reasons. To allow the PI Services developers access for deployment, test, verification etc. a VPN (Virtual Private Network) service was configured. This allows developers to access the internal networks of the PoC environment from their local laptop or workstation as if the laptop was actually part of the PoC environment network. It does so in a highly secure manner ensuring no unwanted access can occur. This scenario is discussed in more detail in the intermediate version of this deliverable (D2.20).

3.3.4 Data Acquisition (D)

One of the core drivers of the PI Services in ICONET is the data provided by the Living Labs. This is reflective of a real-world implementation of the PI and PI Services scenario. The PI Services themselves provide abstraction, common protocols and standards, analysis and prediction among other functions, but they are all powered by the data provided by logistics organisations. This data can be day-to-day operational data such as the exchanging of orders or it can be large scale data for analytics processing, such as a month's worth of data related to late deliveries. The daily operations of data exchange are handled by the Logistics Web Service and the Shipping Service, but large-scale datasets (or data streams) for analytics need a dedicated consumption strategy.

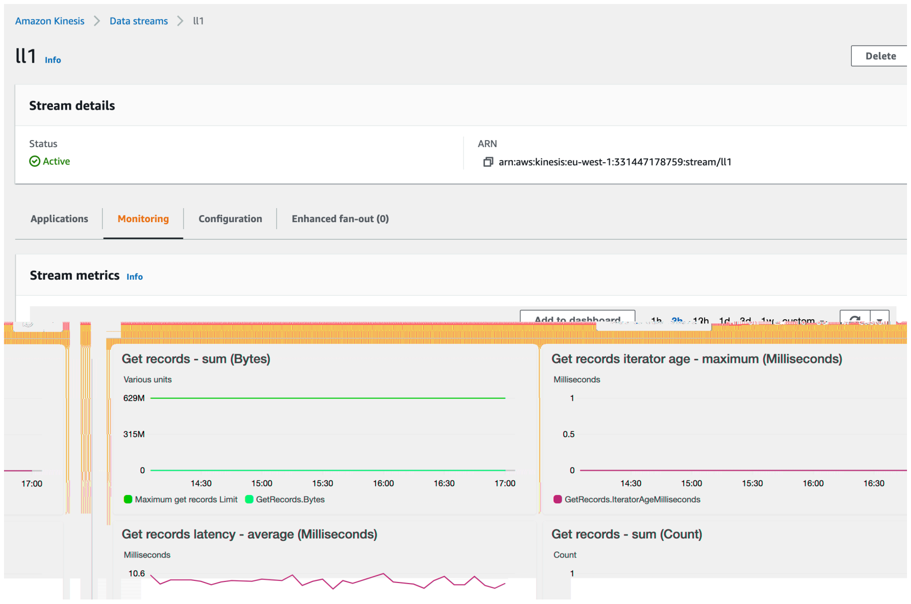


Data streams (4) Info

Data stream name	Open shards	Status
ll1	1	Active
ll2	1	Active
ll3	1	Active

Figure 7 - Living Lab Input Streams

There are a large number of possible strategies for large scale data consumption, but many are based on similar approaches. As shown in Figure 7, within the ICONET PoC a data stream was created for each Living Lab. A data stream is a dedicated API endpoint where data can be submitted via API requests. Data is forwarded to the data stream by an agent which is installed and run at the data source, making API requests to the stream. The agent is simple and light weight and usually works by simply capturing log files as they are generated. Each stream has some configuration options and allows for monitoring of the incoming data to ensure the stream is active and functional. This means that each Living Lab or real-world data source can be monitored independently with regards frequency of data and is an early warning mechanism if data streams fail. Figure 8 below shows the monitoring dashboard for the Living Lab 1 data stream.



Amazon Kinesis > Data streams > ll1

ll1 Info

Stream details

Status: Active

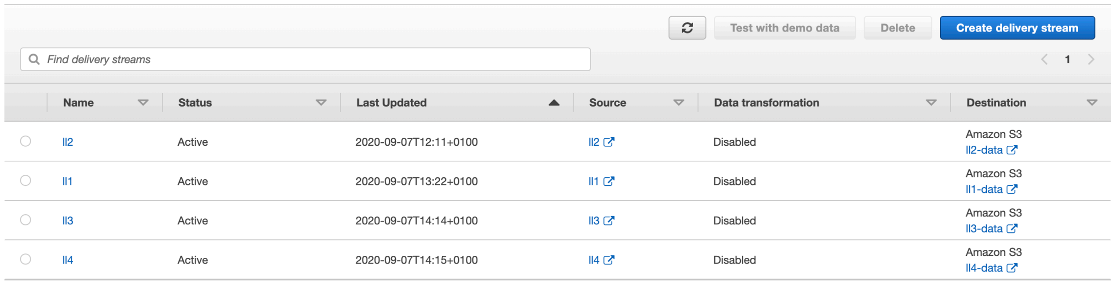
ARN: arn:aws:kinesis:eu-west-1:331447178759:stream/ll1

Stream metrics Info

Delete
Applications
Monitoring
Configuration
Enhanced fan-out (0)
Add to dashboard
Get records - sum (Bytes)
Various units
629M
315M
0
14:30
15:00
15:30
16:00
16:30
17:00
Maximum get records Limit
GetRecords.Bytes
Get records iterator age - maximum (Milliseconds)
Milliseconds
1
0.5
0
GetRecords.IteratorAgeMilliseconds
Get records latency - average (Milliseconds)
Milliseconds
10.6
Get records - sum (Count)
Count
1

Figure 8 - Data Stream Monitoring

The data stream passes the data to a delivery stream. This is essentially a dedicated agent that consumes data coming out of the stream, processes it and sends it to its final destination. The delivery stream has the ability to convert the data into a common format, encrypt it and save it in a dedicated storage slot for this data steam. Each Living Lab has a dedicated data stream, delivery stream and storage space. Figure 9 shows the delivery streams for each Living Lab in the management console and Figure 5 (Point D, bottom left) shows the data ingestion point and the components discussed here. In the case of the ICONET PoC AWS Firehouse and S3 services were used for this. These systems are based on industry standards used in other major tools such as ELK (Elasticsearch Logstash Kibana) and the strategies employed can be reused in these tools if needed.



Name	Status	Last Updated	Source	Data transformation	Destination
ll2	Active	2020-09-07T12:11+0100	ll2	Disabled	Amazon S3 ll2-data
ll1	Active	2020-09-07T13:22+0100	ll1	Disabled	Amazon S3 ll1-data
ll3	Active	2020-09-07T14:14+0100	ll3	Disabled	Amazon S3 ll3-data
ll4	Active	2020-09-07T14:15+0100	ll4	Disabled	Amazon S3 ll4-data

Figure 9 - Living Lab Data Delivery

3.3.5 Node-to-Node Communication & Integration with Legacy Systems

Node-to-Node communication is a critical and key element to the PI concept. In the above scenarios, section PI Service Access (B) discusses the manner in which legacy systems will communicate and access PI Services. The same technologies, approaches and policies will govern how two PI Nodes will communicate. The Shipping PI Service serves as the interface for PI Node to another node, and therefore two Shipping services will exchange information about PI Orders across API gateways. As before, the API gateway will manage the implementation of the authorisation and access, security tokens etc. but this must be managed across multiple nodes. In early PI pilot programs, the PI will essentially be a "network of networks" where two transport and logistics organisations will agree to connect their networks using PI protocols. In these circumstances the management of tokens and authorisation can be handled manually. As the networks grow in numbers of participants it will become impractical to manage authorisation, keys and identity manually and will require central management, likely owned by a local trusted transport and logistics entity such as a port authority.

Integration with legacy systems such as ERP, WMS, TMS is also a critical element in terms of PI Integration. PI systems, in particular for early adoption of PI and PI pilot programs. PI Services will initially be unable to function in isolation and will require significant integration with legacy systems in order for the PI to be leveraged. The exact manner and means of integration falls into distinct layers:

- The business level – this would be where organisations have agreements to connect their networks together. This is a practical and legal process, not a technical one.
- The data level – the PI is the common data model, so that has been already define by GPICS and PI Architecture, however the interface between existing legacy systems and PI Services will be required, and this is a service provided by PI Service developers and IT staff in logistics organisations in a coordinated effort. There can be no "universal adapter" as there are many different legacy systems with their own data models. Although rare currently, standardized data models for logistics are becoming more prevalent in research and industry and should be utilized for PI pilot programs.
- Access level – this is concerned not with what is communicated – but how is relevant to this document. Regardless of the data model the manner and means is likely to be a REST API based communication in line with existing PI Services. Authentication will likely be via authorised token or VPN or a combination of both and these scenarios both align with existing external connectivity scenarios for the PoC Integration Platform. It is possible that an intermediate application such as a "data adapter" is required but this is simply to change the format of the data and something like AWS Lambda using serverless functions can be utilized to do this. Therefore, the combination of API gateways and AWS lambda provide and out-of-the-box approach for legacy integrations with PI Services in a manner and means described in section 3.3.2.

4 Deployment Strategies, Methodologies and Procedures

While ICONET is a research and development action, it is worth considering how the technical assets produced by the project can be adopted in a real-world production engagement. In modern cloud deployments the CI/CD (Continuous Integration/Continuous Deployment) approach is widely adopted and suits the needs of this project well. CI/CD is based on the idea that as a developer commits new code and new changes, these are integrated and deployed immediately as long as they pass a series of tests and verifications. This means that new features and fixes can be made available to users immediately, in opposition to the “scheduled release” approach which requires all changes and updates to be packaged together and all services and components to release these changes in sync. This means updates will be complete but unused while other updates are in development.

4.1 Pipelines

The key mechanic that powers CI/CD is the concept of a pipeline. A pipeline is simply a series of steps that the service or application passes through from code commit though to deployment.

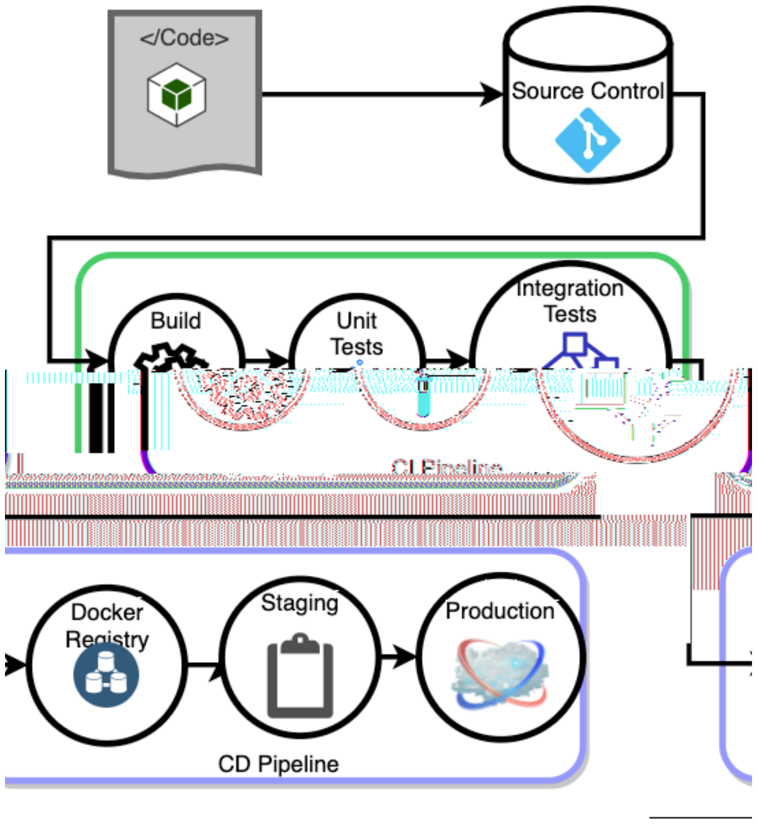


Figure 10 - CI/CD Pipeline

As we can see in Figure 10 a developer will commit a new codebase to the source control repo for that component or service and this will initiate the build process. In the above example the integration phase will build the component, run the unit tests (self-tests) and the integration tests (testing the components behaviour in relation to other components) before moving to the deployment phase. In the deployment phase the service is committed to the docker registry for future re-use if needed, deployed into the staging environment and then deployed into production. All PI Services in the ICONET PoC are deployed into AWS Fargate clusters. Fargate is a serverless compute engine that the Elastic Container Service uses to run containerised applications. Fargate has been discussed in more detail in the intermediate version of this deliverable (D2.20). It should be noted however this is just one potential pipeline configuration, it is possible to add any number of stages in the pipeline depending on requirements. For example, a security audit and evaluation is another common stage that pipelines will include. As already stated, this project was to focus on the use of PaaS as much as possible, so the pipeline systems provided by AWS were leveraged. However major pipeline systems available from other cloud vendors or open source options such as Jenkins are very similar in their approach and use in that they accept assets and resources from external sources or previous steps, perform and action and based on the results perform one or more subsequent steps. On AWS the pipeline is provided as part of the AWS developer tools:

1. CodeCommit: This allows you to create source control repos. ICONET has 17 different source code repositories for various versions and sub-components of the services developed for WP2.
2. CodeArtifact: This allows storage and version control of artifacts created as part of a build process (for example a java library jar file)
3. CodeBuild: This allows for the building of applications. In the case of ICONET all services are containerised, so the build phase builds docker images using the Dockerfile in the source repository and packages in the source code and dependencies required for the image.
4. CodeDeploy: This tool allows the creation of “applications” to define how multiple components and services might make up a single application. Then this application can be deployed using images from the build phase into either a staging environment or straight into a production environment. In the case of ICONET services are deployed into ECS (Elastic Container Service) Fargate clusters.
5. Pipeline: This is the tool that allows the creation of an actual pipeline composed of the previous 4 tools. As we can see in Figure 11, the codebase and docker registry make up the source phase of the pipeline, then there is a test phase and finally a deployment phase, but it’s possible to add an intermediary stage at any point in the pipeline such as a security audit.

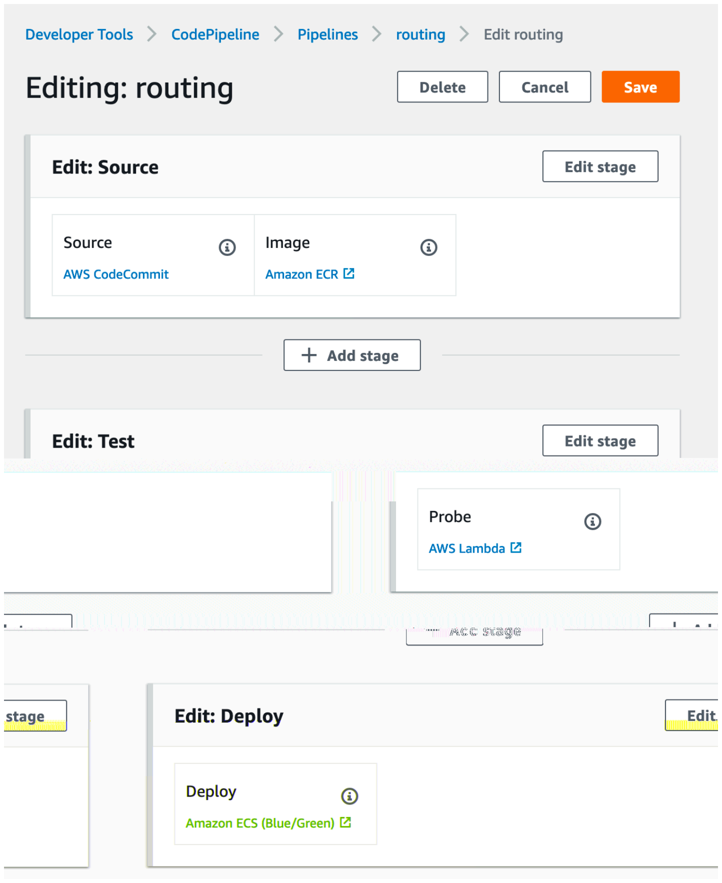


Figure 11 - Routing Pipeline

4.2 Recommended Pipelined Testing Strategies

There are a number of potential approaches for testing the PI services before deployment. If a PI Service developer has included a set of unit tests, then it’s simply a matter of running these tests. The creation of Unit, API and Integration tests are part of the development process and outside the scope of this deliverable. However, IBM did build out the frameworks and pipelines to support testing, as well as implement the security audit process as discussed below.

4.2.1 Unit Tests

Unit tests are a set of functions provided by the developers that ensure that for a given set of inputs, expected outputs are received for the various internal components of a service. To avail of this one can either launch the docker image with some specific command line variables passed, to initiate the tests, or one can check out the codebase and run the tests directly. Which approach will depend on the type of approach chosen by the developer. Both are supported by the AWS Developer toolkit.

4.2.2 API Tests

API Tests will simulate real requests to the API service and verify that responses returned are accurate. These tests are not always applicable as some services will have multiple downstream dependencies that are required for the API responses to be delivered. However, some services do not have such a reliance or can be adapted to not need one. For example, the routing service depends on the networking service, but the routing service has been designed to allow the static upload of a PI network. This allows the service to be tested by ensuring the correct routes are returned. To perform these tests AWS Lambda can be used. As discussed in D2.20, version two of this deliverable, AWS Lambda is a serverless code execution engine. This allows relatively simple scripts or code to be written on run on a schedule or as needed. In this instance AWS lambda can make a HTTP API REST request to the service being tested, verify the result and return a PASS or a FAIL.

4.2.3 Integration Tests

a number of inherited images that it is built upon. Each with a vast array of potential security audit points. In addition to that almost all PI Services are built using python. As part of the process of building a docker image the python dependencies are installed. These are libraries that the PI Service application will need in order to function correctly. The developer has full control to add as many dependencies as they see fit from any number of potential sources. The resulting docker image will contain the PI Service code but will also contain a large number of "unknowns" in terms of base image components, libraries etc.

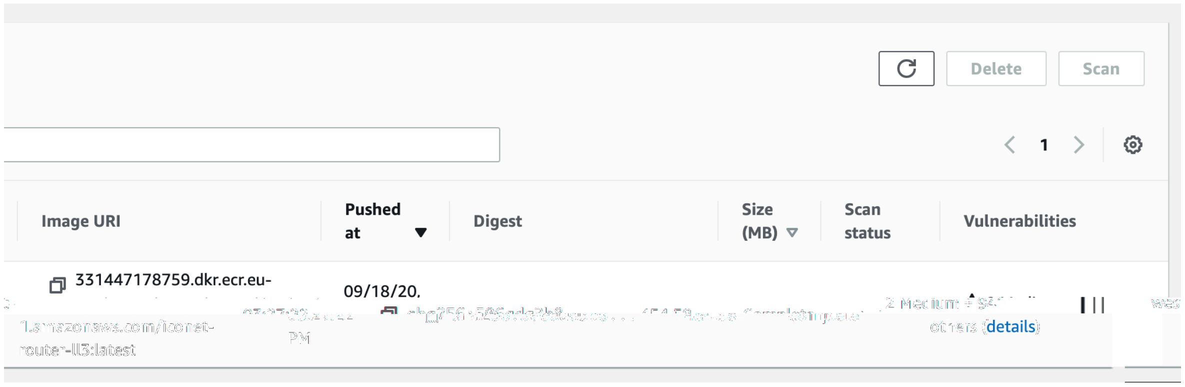
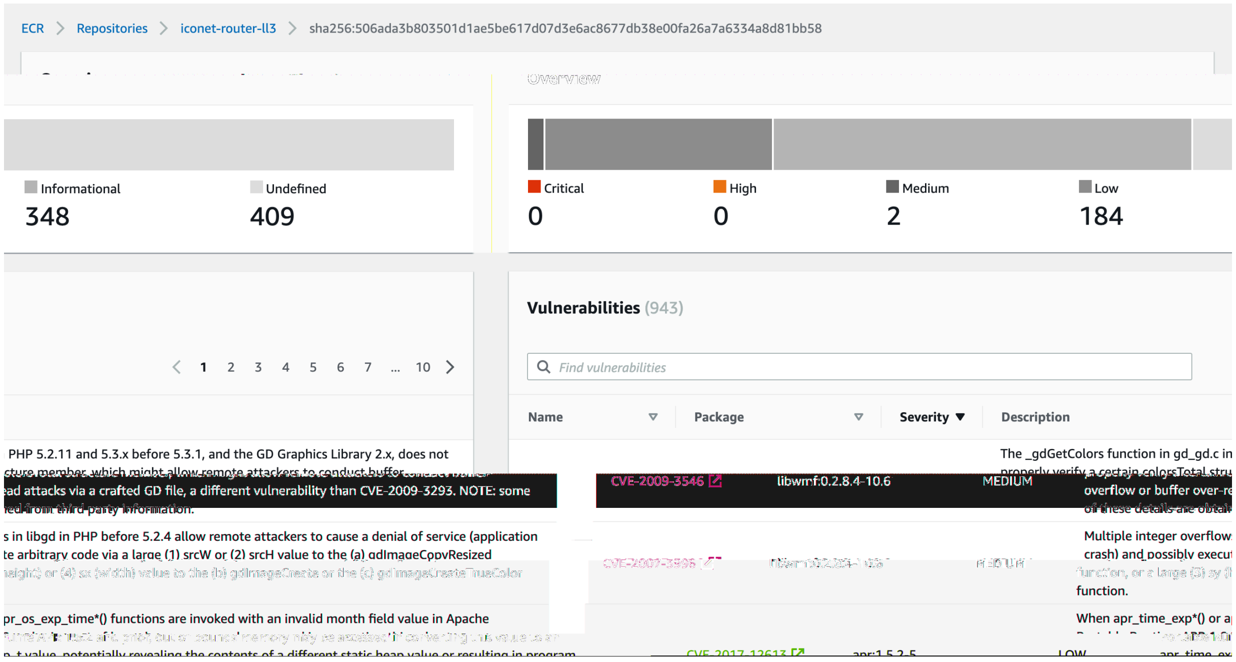


Image URI	Pushed at	Digest	Size (MB)	Scan status	Vulnerabilities
331447178759.dkr.ecr.eu-[illegible]1.amazonaws.com/iconet-router-ll3:latest	09/18/20, [illegible] PM	[illegible]	[illegible]	[illegible]	2 Medium + [illegible] others (details)

Figure 12 - Vulnerability Notification

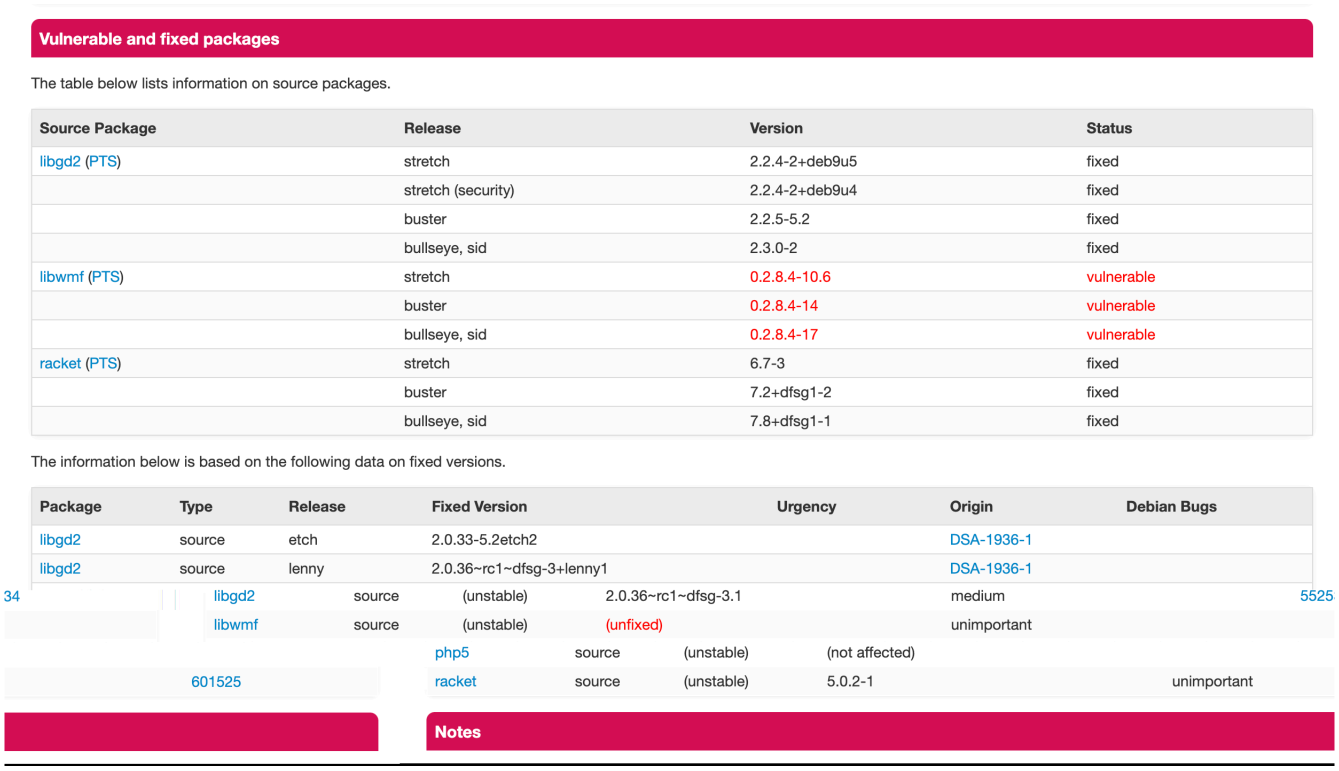
It's not feasible to audit these by hand so a docker image audit tool is used to perform this. As seen in *Figure 12*, In the case of ICONET, the audit tool allows for images to be scanned as they are pushed to the registry, and a notification generated if the resulting report requires attention. An example report is shown in *Figure 13*. The report indicates two medium severity CVEs (Common Vulnerability or Exposure). However, there are a number of open source and commercial alternatives such as Anchore or Clair.



Name	Package	Severity	Description
CVE-2009-3546	libwmf:0.2.8.4-10.6	MEDIUM	The _gdGetColors function in gd_gd.c in PHP 5.2.11 and 5.3.x before 5.3.1, and the GD Graphics Library 2.x, does not properly verify a certain colorsTotal structure member, which might allow remote attackers to conduct buffer overflow or buffer over-read attacks via a crafted GD file, a different vulnerability than CVE-2009-3293. NOTE: some of these details are obtained from third party information.
CVE-2007-3996	[illegible]	MEDIUM	Multiple integer overflows in libgd in PHP before 5.2.4 allow remote attackers to cause a denial of service (application crash) and possibly execute arbitrary code via a large (1) srcW or (2) srcH value to the (a) gdImageCopyResized function, or a large (3) sy (height) or (4) sx (width) value to the (b) gdImageCreate or the (c) gdImageCreateTrueColor function.
CVE-2017-12613	apr:1.5.2-5	LOW	When apr_time_exp*() or apr_os_exp_time*() functions are invoked with an invalid month field value in Apache Portable Runtime APR 1.6.2 and prior, out of bounds memory may be accessed in converting this value to an apr_time_exp_t value, potentially revealing the contents of a different static heap value or resulting in program

Figure 13 - Vulnerability Report

Clicking the CSV link on the left will bring more detail on the CVE and how to resolve as shown in the detailed report in Figure 14. In this instance, we can see three versions of this library that are vulnerable to attack, so changing to any of the known fixed versions will resolve the issue. In this circumstance the issue was with the base docker image, not the developers code, so to update it will require rebuilding the base image with the libraries updated.



Vulnerable and fixed packages

The table below lists information on source packages.

Source Package	Release	Version	Status
libgd2 (PTS)	stretch	2.2.4-2+deb9u5	fixed
	stretch (security)	2.2.4-2+deb9u4	fixed
	buster	2.2.5-5.2	fixed
	bullseye, sid	2.3.0-2	fixed
libwmf (PTS)	stretch	0.2.8.4-10.6	vulnerable
	buster	0.2.8.4-14	vulnerable
	bullseye, sid	0.2.8.4-17	vulnerable
racket (PTS)	stretch	6.7-3	fixed
	buster	7.2+dfsg1-2	fixed
	bullseye, sid	7.8+dfsg1-1	fixed

The information below is based on the following data on fixed versions.

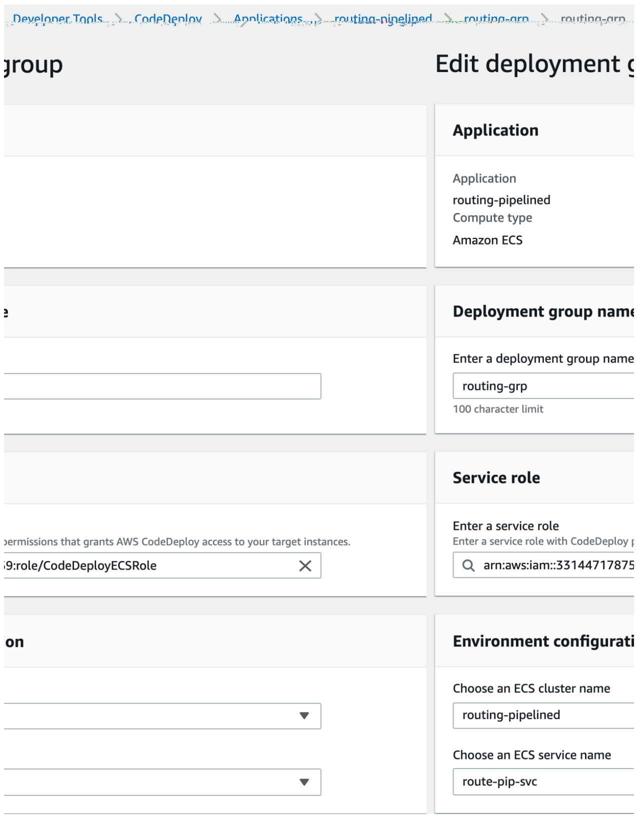
Package	Type	Release	Fixed Version	Urgency	Origin	Debian Bugs
libgd2	source	etch	2.0.33-5.2etch2		DSA-1936-1	
libgd2	source	lenny	2.0.36~rc1~dfsg-3+lenny1		DSA-1936-1	
34 libgd2	source	(unstable)	2.0.36~rc1~dfsg-3.1	medium		5525
libwmf	source	(unstable)	(unfixed)	unimportant		
php5	source	(unstable)	(not affected)			
racket	source	(unstable)	5.0.2-1	unimportant		601525

Notes

Figure 14 - CVE Information

4.4 Deployments

The final phase of the pipeline is deployment. There are two deployment paradigms that have been considered. In the case of a less substantial update – for example a minor bug in the UI (User Interface) of a web service - a typo. To fix this a single service needs to be updated and it has minimal or no bearing on other services. Services are packaged within the AWS dev-ops tools as applications. An application may comprise of one or more services that are linked closely together. For example, the routing service operates by itself so an application definition comprises of a single service. However, the IoT service is made of multiple services, so the IoT Container tracking application is comprised of all these services. The application also manages the historical revisions of the application and components that were deployed in the past. This facilitates rolling back to known functional versions in the event of a faulty deployment.


Developer Tools > CodeDeploy > Applications > routing-pipelined > routing-grp > routing-grp

Edit deployment g

Application

Application
routing-pipelined
Compute type
Amazon ECS

Deployment group name
Enter a deployment group name
routing-grp
100 character limit

Service role
Enter a service role
Enter a service role with CodeDeploy
arn:aws:iam::33144717875

Environment configurati
Choose an ECS cluster name
routing-pipelined
Choose an ECS service name
route-pip-svc

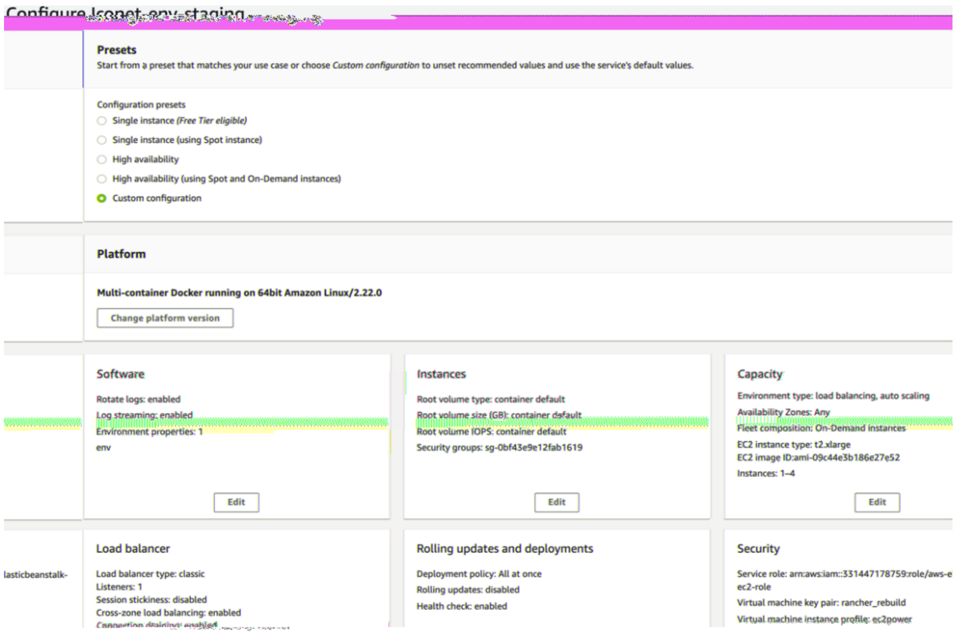
ermissions that grants AWS CodeDeploy access to your target instances.
9:role/CodeDeployECSRole

Figure 15 - Deployment Group

Within an application, a deployment group is configured for each PI Service. As seen in Figure 15, the deployment group allows for the definition of where the PI Service will be deployed to, specifying which Fargate cluster and which service definition within that cluster to use. The deployment group also defines the load balancer and port assignments of the PI Service and finally the traffic rerouting strategy.

The traffic rerouting strategy allows for the setting of a deployment schedule by specifying a specific time to remove the old service and deploy the new one. An approach here could be to engage the deployment at night when there are little or no users if the service is only used during the day. The traffic rerouting strategy can also set rate of rerouting. For example, every hour redirect and additional 10% of the traffic to the new deployment until the old deployment is receiving no traffic. This allows for careful monitoring of the new service or deployment an ensures issues are highlighted in time to reverse the deployment.

An alternate strategy for deployments is to use a staging environment. This is more applicable for deploying much more significant changes that encompass multiple PI Services acting together, such as a new standard or policy. In this situation there are two production environments available. One is accepting traffic from users, while the other is used to deploy the latest service versions. The components have already been tested via the pipeline, but some validation and testing can take place of the environment overall. Once this is done, the endpoints that users are using to access the environment is switched from the existing live environment to the staged. This is instantaneous and there is no downtime from the user's perspective. Once again, if any issues are observed, the endpoints are simply swapped back to the known good environment.



Configure Iconet-env-staging

Presets
Start from a preset that matches your use case or choose *Custom configuration* to unset recommended values and use the service's default values.

Configuration presets
- Single instance *(Free Tier eligible)*
- Single instance (using Spot instance)
- High availability
- High availability (using Spot and On-Demand instances)
- [✓ Custom configuration]

Platform

Multi-container Docker running on 64bit Amazon Linux/2.22.0

Software
Rotate logs: enabled
Log streaming: enabled
Environment properties: 1
env

Instances
Root volume type: container default
Root volume size (GB): container default
Root volume IOPS: container default
Security groups: sg-0bf43e9e12fab1619

Capacity
Environment type: load balancing, auto scaling
Availability Zones: Any
Fleet composition: On-Demand instances
EC2 instance type: t2.xlarge
EC2 image ID:ami-09c44e3b186e27e52
Instances: 1–4

lasticbeanstalk-

Load balancer
Load balancer type: classic
Listeners: 1
Session stickiness: disabled
Cross-zone load balancing: enabled
Connection draining: enabled

Rolling updates and deployments
Deployment policy: All at once
Rolling updates: disabled
Health check: enabled

Security
Service role: arn:aws:iam::331447178759:role/aws-e
ec2-role
Virtual machine key pair: rancher_rebuild
Virtual machine instance profile: ec2power

Figure 16 - AWS Beanstalk Configuration

AWS abstracts this process out using a tool called beanstalk. Beanstalk allows you to clone an environment once it has been deployed once and manages the public endpoints to that environment. This then allows for multiple versions of an environment to be easily recreated and multiple deployment pipelines configured as requirements need. For example, there may be a live environment, a staging environment and a demo environment (which allows critical customers to view potential new features and give feedback while development is still underway). Beanstalk allows for centralised management of all environments and some of the specifics within those environments also, as shown in Figure 16.

5 Machine Learning Deployments

A number of PI Services either currently or will in the future leverage machine learning technology. These services will still be leveraged via REST APIs as the other services are, but with a different analytical approach behind the API interface. As seen in the **Deployment** section, the cycle for other services is straightforward:

- Developer checks in new code
- Code is built into a service
- Service is tested, audited, verified
- Service is deployed

However, services that are based on machine learning approaches require a different approach to pipelines and deployments. The basic process for the development and creation of a machine learning API service covers the following:

1. Data acquisition – All machine learning research requires significant datasets to work with for training and validation.
2. Data Curation – Removing Data that is not relevant. For example, if analysing traffic patterns for commuting rush hour, weekend data can be removed completely.
3. Data pre-processing – the data may not be in a desirable format and will need to be converted depending on the tools being used and the formats they will accept
4. Definition of a machine learning approach or algorithm - This is the main task of the develop, ensuring they pick an approach that matches the datasets and goals of the research
5. Training the machine learning model – this is the most computationally (and monetarily) expensive and time-consuming part of the process. The time required will vary vastly depending on the hardware available for training. CUDA GPUs will increase the speed at which training can take place but these components are extremely expensive to purchase and equally expensive to rent through a cloud provider.
6. Trained model is verified against the dataset – The dataset is usually split into two parts, one to train and one to validate the model. Once the model has been validated to some chosen metrics (such as accuracy or rate of false positives, false negatives etc.)
7. The model is deployed to an API service that accepts requests, passes them to the model, captures the results and returns them to the requestor.

5.1 Requirements for new Machine Learning Deployment

As can be observed, there are a number of additional steps and there are now more than one places where a change could initiate the requirement for a new service deployment:

1. The quality of the datasets for training changes
2. The format of the datasets for training changes
3. The developer changes the algorithm or approach (or alters the existing approach slightly)
4. A new dataset is provided

The last option, number 4 is of course the most common and most frequent. A machine learning service is only as good as the data that it has been trained on. Therefore, any analytics being done on data that changes periodically, seasonally or in line with other trends (financial, or consumer for example) will require new models trained on data that represents these latest trends. A simple example of this would be any analysis of the product choices consumers make for delivery during the summer would be meaningless during the months leading up to Christmas. Similarly, analytics noting an increase in Pumpkin sales during the month of October will likely not be relevant during the rest of the year.

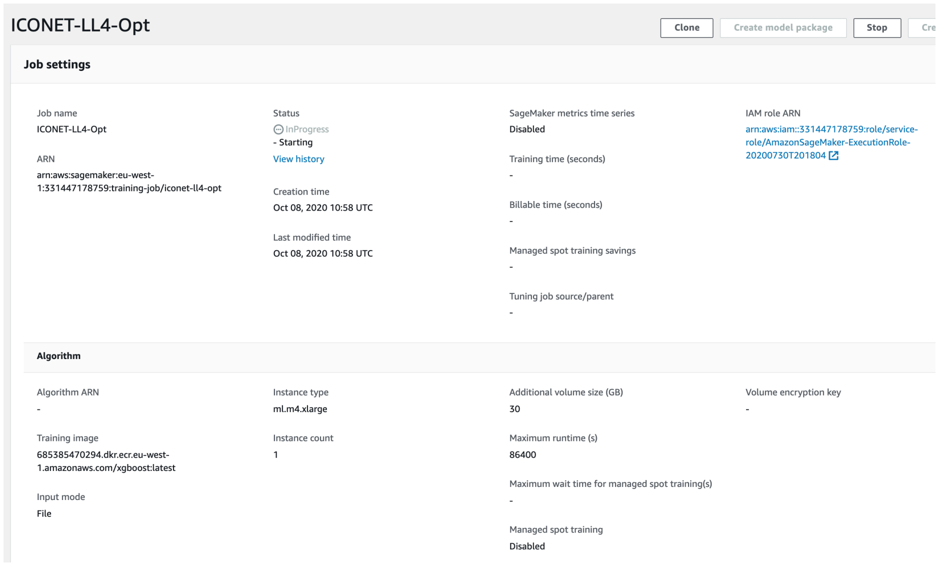
5.2 Microservices Approach

The initial development process combines the actions of curation, pre-processing, model definition and training into a single application or script. This works well at early development as the developer can make multiple changes in parallel however as the application approaches production, we see issues with this. A change to the pre-processing method should not require us to retrain the image. Therefore, an emerging trend is to split the actions into individual microservices, each dedicated to a specific task. This allows updates to one service without interference with another. In the case of ICONET these services are docker based (as are all components in ICONET) which allows them to be pipelined and deployed in the same manner as the other PI Services and using approaches discussed in the **Deployment** section.

5.3 Model Training as a Service

However, there is an exception to this approach – the model training service will require access to specific hardware. This is both expensive and complicated as most PaaS offerings do not easily allow access to such hardware in their container compute services. One alternative is to purchase (or reserve) some dedicated hardware with a GPU installed, but this is expensive and also not very cost effective as models are only trained periodically.

PaaS offerings that are specifically design for machine learning are the best approach here. They will utilise industry standard tools (such as Jupyter Notebooks) to allow developers to migrate their algorithmic approaches to model training into the cloud. For the ICONET PoC AWS Sagemeker was used but all major cloud vendors have similar services such as IBMs Watson Machine Learning or Google’s AI Platform. This allows models to be trained as needed in the cloud. This brings a number of advantages, the first of which is cost. Since the hardware is only engaged for the time needed to train the model, there is no lost cost to hardware sitting idle. Additionally, there is no overhead in terms of administration or setup for dedicated hardware and because the models are trained using a PaaS service, they accessible by other PaaS systems such as the pipeline tools and deployment tools.



ICONET-LL4-Opt

Job settings

Job name ICONET-LL4-Opt	Status InProgress - Starting View history	SageMaker metrics time series Disabled	IAM role ARN arn:aws:iam::331447178759:role/service-role/AmazonSageMaker-ExecutionRole-20200730T201804
ARN arn:aws:sagemaker:eu-west-1:331447178759:training-job/iconet-ll4-opt	Creation time Oct 08, 2020 10:58 UTC	Training time (seconds) -	
	Last modified time Oct 08, 2020 10:58 UTC	Billable time (seconds) -	
		Managed spot training savings -	
		Tuning job source/parent -	

Algorithm

Algorithm ARN -	Instance type ml.m4.xlarge	Additional volume size (GB) 30	Volume encryption key -
Training image 685385470294.dkr.ecr.eu-west-1.amazonaws.com/xgboost:latest	Instance count 1	Maximum runtime (s) 86400	
Input mode File		Maximum wait time for managed spot training(s) -	
		Managed spot training Disabled	

Figure 17 - Sagemaker training job in progress

Once the training and algorithmic approach is defined, this can be created as a training job as shown in Figure 17. Combined with new data either being streamed or manually uploaded to a dedicated storage location, this allows training jobs to be run on a predefined schedule, occurring frequently enough to account for any trends in the dataset (weekly, monthly, etc.). The resulting models are then stored in in a dedicated storage location within the cloud and are accessible for further use as shown in Figure 18

Figure 18 - Saved Model

5.4 Machine Learning as a Service

At this point, the model has been trained as is available in an S3 storage bucket (AWS refers to storage locations as “S3 buckets”). There are two available approaches from this point forward. It is possible to use the arrival of new model in S3 to trigger a pipeline build similar to the pipeline described in the **Pipelines** section. In fact, much of the pipeline can be reused, aside from the triggering incident (a new model instead of new code. A machine learning based service is built into a docker image in the same manner as any other PI service, however as part of the build process it will import the model from S3.

The alternative approach is to avoid the use of docker images entirely. Usually, the bulk of the processing work in a machine learning based service is performed by the model itself, and the docker image and other code within are simply there as frameworks to support the use of this model, usually to simply accept requests via REST API and pass the data provided to the model, capture the result and return it to the requestor. Since this functionality is both simple and likely to be similar for any service that relies on a machine learning model, we can implement it using PaaS in a much more efficient, secure and cost-effective manner.

Figure 19 - Machine Learning Endpoint - PaaS Powered

Figure 19

1. The client – this is likely another PI Service or a 3rd party logistics management tool that is availing of machine learning analytics.
2. The API Gateway – Also seen in **the Integration Strategies & Approaches** section, this tool provides a public facing interface to the API. Through a simple configuration process the API Gateway can handle some non-functional mechanics such as authentication keys, authorisation, certificate management and so forth. Requests are made directly to the API Gateway and once the authentication & authorisation elements are validated, the request is passed on (in this case) to AWS Lambda.
3. Lambda is a serverless execution engine provided by AWS. Serverless execution allows for relatively simple applications or scripts to be run without the overhead of managing the libraries or underlying compute such as docker, Kubernetes, virtual machines etc. In this case the code that captures the request data from the API request and passes it to the machine learning model is implemented as a lambda function because it is quite straightforward.
4. AWS Sagemaker provides an endpoint for a given machine learning model, as a single point of access for entry. This can take some configuration in terms of the compute resources allocated to the endpoint and also serves as a point of monitoring where some metrics such as rate of request can be captured.
5. The endpoint sends requests to a load balancer which distributes them across however many compute resources are available. It is possible to configure the endpoint compute nodes to scale automatically as needed – adding additional nodes as the rate of requests or complexity of requests increases ensures there is no degradation in performance but ensures there is no cost for hardware sitting idle either.

On the lower half of Figure 19 we see the general steps for the creation of the models that the endpoint is using. Data is either stream or uploaded (more details in **the Integration Strategies & Approaches** section) and is stored in S3 storage buckets. The data is used to train new models which are deployed by Sagemaker to the model endpoint. What is noteworthy here is that aside from the core work of designing an algorithmic approach that the model will use, there is no further overhead from a development perspective. A data scientist can do effective and useful work without the support of additional developers and with minimal training in the AWS services that support the service.

Looking to the future, low power edge devices operating in a fog network will be utilized for inference based on machine learning models. This can also be combined with the concept of distributed learning, which spreads the analytics across a variety of devices in a fog network with dispirit data sources, allowing for more accurate analytics. This is discussed in more detail in the following section.

6 Future Trends in PI Service Deployment Models

The core goals of this deliverable and associated tasks were to provide a digital workbench that facilitated the deployment, development and integration of the PI Services and other services and systems utilized in WP2. Beyond that research was done to explore the non-functional considerations regarding the deployment, security and access scenarios that the PI Services may need to be coupled with. However, it is valuable to consider the potential deployment models that will be prominent as the PI begins to be introduced to real world logistics operations in early pilot programs.

The EU has already identified emerging trends in cloud computing and has directed H2020 funding towards projects exploring these future-looking computing paradigms. One of the major themes is to explore and facilitate the “Cloud to Thing Continuum”.

In the last decade, more and more major organisations are moving away from traditional “On Premise” models (where they deploy and manage their own data centres, equipment etc.) and moving their IT operations to the cloud, usually engaging a major cloud vendor such as Amazons’ AWS, Google’s GCE, Microsoft, Azure or IBM Cloud. However, in more recent years industry leaders like IBM are exploring trends moving towards the concept of a hybrid approach. Combining the cost effectiveness of the cloud with the security and control of a private datacentre (or private cloud). This has then further led to the concept of multi-cloud – where an organisation should be able to engage multiple cloud vendors as well as their own datacentres, to leverage the strengths of

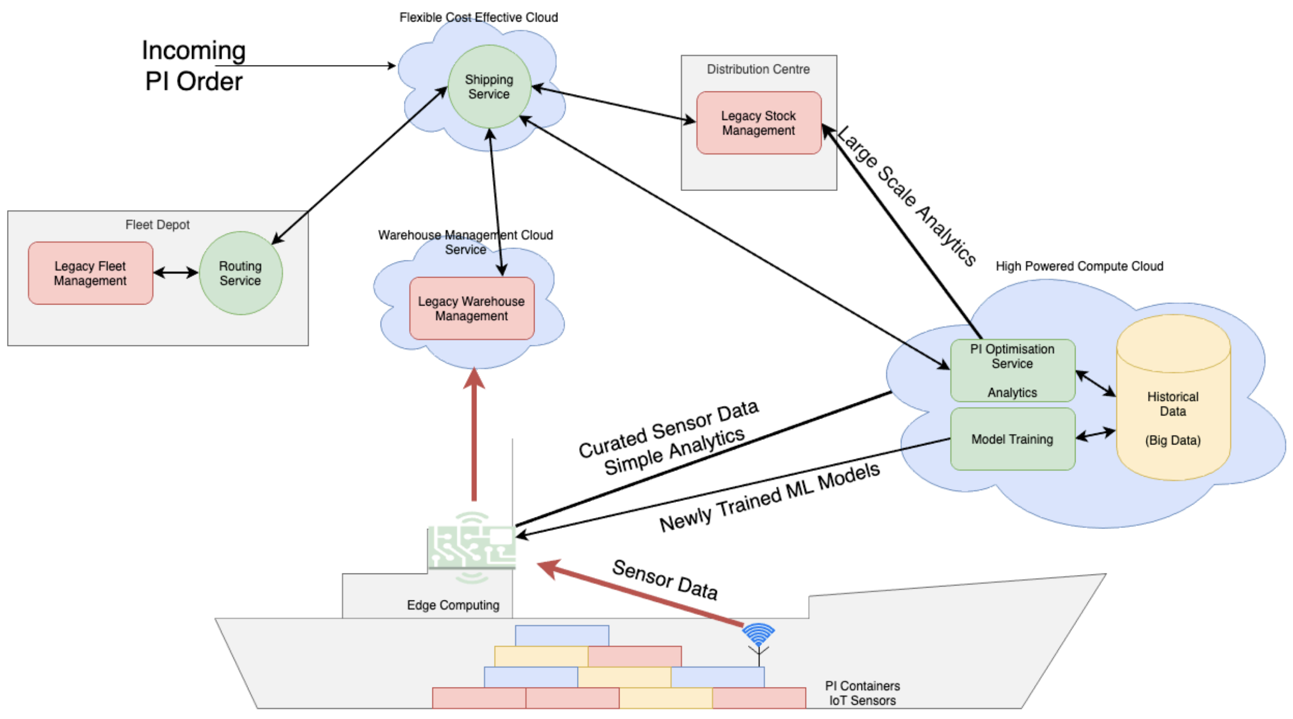


Figure 20 - Multi Cloud PI Example

In Figure 20 we propose a possible scenario in the future of PI and how it relates to current trends in cloud and edge computing. This example focuses on a logistics entity or node with a number of operational requirements. During the initial adoption of PI it is likely that existing legacy IT systems will still play a major role in the logistics operations of this organisation. In this scenario the logistics organisation uses three in-house systems – a Warehouse Management System, a Fleet Management System and a Stock Management System. The three systems share information and coordinate as needed and these systems are often deployed (but not always deployed) at the premises where they are used – for example the fleet management system is running on a server at the depot where the fleet operates out of but the warehouse management system is a cloud based software solution. In addition, the logistics organisation is leveraging the PI and has deployed its own tailor customed Shipping Service which serves as the entry point of this organisation into the PI world. They have also deployed the routing service and are engaging the PI Optimisation analytics service. From Figure 20 there are some points to note:

- The shipping service has been deployed into a simple, cost effective cloud vendor as the compute requirements and resources needed for the shipping service are low. It should be easy to update and manage it and require little overhead and be as cost effective as possible
- The Routing Service was deployed in an on-premise setting because the fleet management system is deployed at the depot and the two services are closely coupled and integrated.
- The Warehouse management system is an out-of-the-box SaaS offering that operates entirely in the cloud and is provided by a 3rd party.
- The PI Optimisation Service performs much more compute intensive and expensive operations, so is deployed in a cloud vendor suited to this
- There are IoT Sensors on shipping containers that report a number of metrics at all times, but they have no memory for resource optimisation reasons.
- However, many modern trucks, trains, ships etc have edge devices to receive sensor readings and some initial analysis and data curation of the sensor data takes place here.

- The PI Optimisation service consumes large scale data from multiple edge devices across multiple PI movers which fuel analytics

This example highlights the many and varied likely communication lines in this scenario – there is almost every conceivable data path occurring. Cloud vendors to other cloud vendors, cloud vendors to private clouds, legacy systems to cloud systems, edge devices to cloud devices, sensors to edge devices and so on. Centralised management of the systems, communication and orchestration of the applications within these systems is an extremely complex challenge to overcome.

6.2 A Centralised Multi-Cloud Management System

As the multi-cloud paradigm is still somewhat recent there are a relatively small number of emerging multi-cloud management solutions. Because this is a recent trend it's difficult to identify a single industry leader. Indeed, there are solutions provided by IBM, Redhat, Cisco, Dell, Citrix Rackware and many more. For this deliverable we elected to focus on Redhat as Redhat technologies also underpin a lot of existing open source and PaaS frameworks discussed in this document. Redhat provide a number of tools that each play a role in addressing the issues above. It should be noted that the Redhat (or any other) multi-cloud management tools should be considered as tools to work in tandem with existing cloud vendor PaaS systems. However, before discussing multi-cloud management solutions it is necessary to re-examine cloud vendors and some private cloud tools from a new angle.

6.2.1 Public & Private Cloud APIs and CLIs

In this document so far, we have seen a number of screenshots showing the management interfaces for AWS tools and services. However, the GUI (Graphical User Interface) is not the only means to control and configure these services. AWS also provides a CLI (Command Line Interface) and API access. The CLI allows individual users to make changes and configurations, create and destroy assets and more via a text interface only. This is sometimes more desirable than using the GUI as it maybe be faster or easier if there is a lot of configuration text to be entered. However more significantly the CLI tool can be used by automation scripts or tools. Dev-ops engineers can write scripts in a language of their choice to automate certain actions using the CLI tool.

API access performs much the same role, except it is designed only to be used programmatically or by automation tools, not manually by a user. Both approaches use secure authentication as standard (username and password for the CLI, tokens for the API) and are widely used and well documented. These tools are provided by all the leading cloud vendors (Google, Microsoft, IBM, Amazon, etc.) but they are also often provided by private cloud frameworks such as Openstack, VMware, Kubernetes, etc. Many tools and products that perform other functions also provide CLI or API access (or both) such as networking systems (firewalls, switches), load balancers (F5), storage clusters (Ceph) and more.

With so many interfaces for so many different products and services it is possible to create complex overarching automation but there is a heavy overhead to creating, managing and maintaining these frameworks. However, much of the work has already been done by Redhat Ansible.

6.2.2 Redhat Ansible

Ansible is an automation framework that operates through the command line using "playbooks". A playbook is simply a series of steps to be completed in a specific order. Playbooks are text files that indicate requirement before a step is taken, how to take that step and then a way to validate the step was successful before moving on. Ansible has a vast catalogue of libraries that allow it to interface with a huge number of products and services. Everything from local systems to cloud vendors are available. An automation task could be as simple as creating a folder and moving a file to as complex as creating a virtual private cloud and associated networks in AWS and provisioning 100 VMs (Virtual Machines) into it.

There are many pre-existing playbooks to perform commonly performed actions (such as the ones mentioned above) but if a playbook does not exist it can be created by a dev-ops engineer or adapted from an existing playbook.

While Ansible is excellent for preforming automated and complex tasks at scale, it is not designed for ongoing maintenance and visibility. This role is fulfilled by RedHat CloudForms.

6.2.3 Redhat Cloudforms

CloudForms makes use of the existing API and CLI access routes to public and private cloud tools as well as the automation frameworks provided by Ansible to give a centralised management platform for a multi/hybrid cloud environment. This platform gives centralised visibility of all resources in use across all resource providers as well as facilitating creation, control and configuration of PaaS services and compute resources.

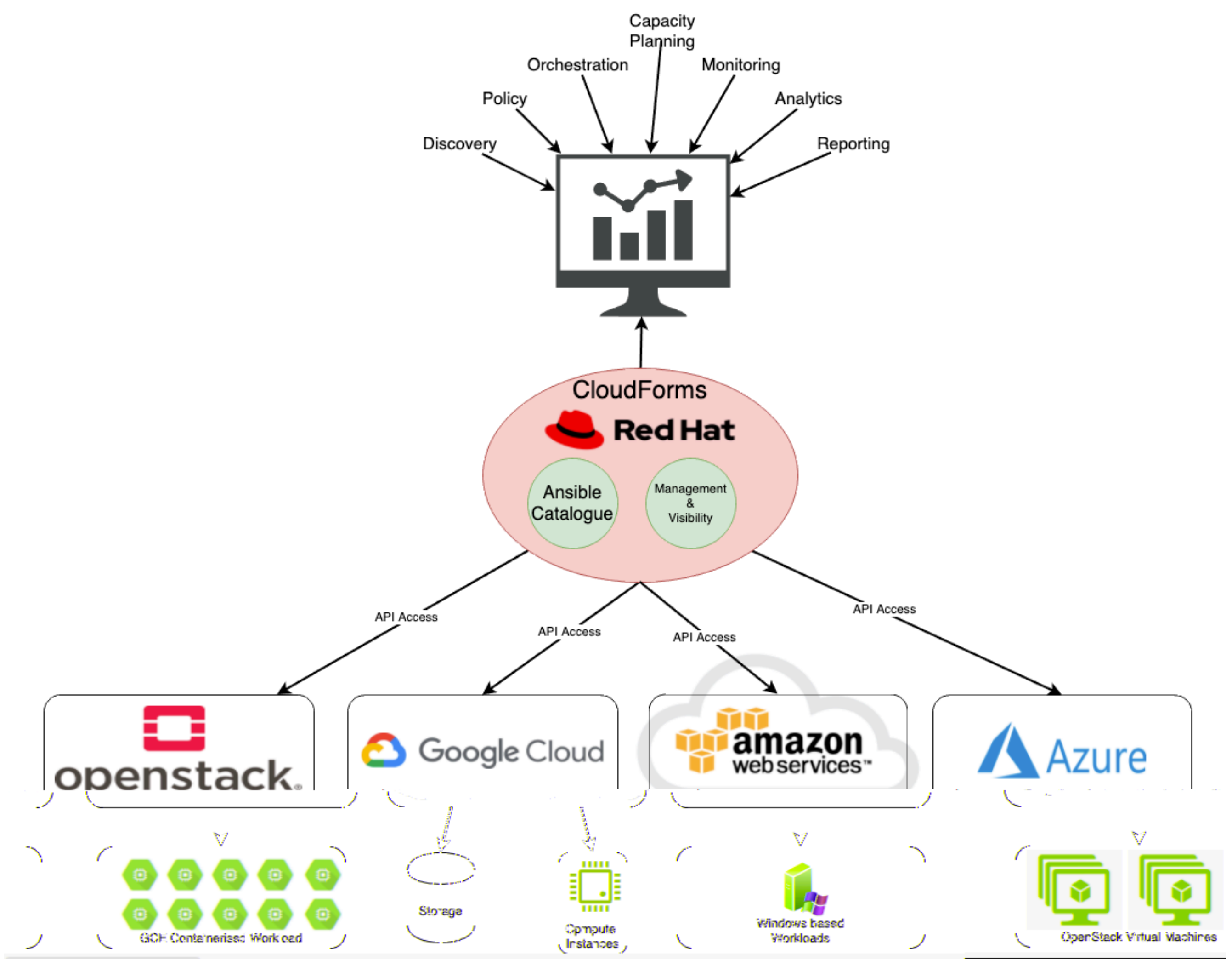


Figure 21 - Redhat Cloudforms

As we can see in Figure 21 CloudForms provides an interface to a number of different public and private cloud providers through API access, which allows for a flexible range of different workload types and resource types. In this instance CloudForms is managing traditional VMs from Openstack, a containerised workload from GCE, pay-per-use dynamic services from AWS and MS Windows based workloads from Azure. The management interface for CloudForms allows for a number of features:

- Insight – This gathers information about resources across all providers to give a single point view of the status of workloads, and offers recommendations based on status
- Control – This allows for orchestration of workloads across multiple providers. Each cloud vendor will of course provide its own solution for workload orchestration (this allows for automatic scaling, healing etc.) but CloudForms enables orchestration across providers, allowing workloads to be moved towards or away from certain providers depending on the workload requirements.
- Automate – Complex automated workflows can be created that leverage multiple providers in cooperation to create, configure or destroy resources and design workloads
- Integration – CloudForms can be integrated with a number of existing industry standard automation tools and API interfaces for significant customisation

6.2.4 Multi/Hybrid Cloud Networks

While CloudForms will provides a centralised manner in which to configure resources across multiple resource providers, it is worth noting that it will not automatically allow for those providers to communicate with each other, and without this communication path the power of CloudForms or any multi-cloud environment is highly limited. Therefore, it is necessary to formulate secure communication paths between environments on different cloud providers.

SDN (Software Defined Networking) provides a universally adoptable approach for this. As we've seen in the Integration Strategies & Approaches section in this deliverable and also in the intermediate version of this document (D2.20), Software Defined Networks have been utilised in the creation of the Proof of Concept (PoC) environment for ICONET. This is based largely on the concept of the Virtual Private Cloud (VPC) which is a private network space that administrators can create to contain whichever resources and assets they wish to deploy. The VPC can be further configured into different zones and virtual networking functions are used to create subnets, switches, routers, NAT gateways, public gateways, DNS servers and so on. VPCs are highly secure and both public and private access routes can be carefully configured to maintain this security.

For two private cloud environments to communicate directly there are a number of options available but there are two common approaches. The first being public API access. This has been discussed in the **Integration Strategies & Approaches** section, and involves APIs that are open to the public internet that provide access to functions or resources within the environment. The advantage to this is that there is minimal configuration required, but the disadvantage is that any public facing interface comes with some security risks. Therefore, sturdy security and authentication measures are needed to secure any public facing API. Most cloud vendors will provide these functionalities, private cloud environments may need more manual configuration. The alternate, more secure option to use VPN (Virtual Private Network) connections. In the intermediate version of this deliverable (D2.20) VPNs were discussed as the manner in which developers created secure connections to the VPC for the PoC from their laptops or desktops. However, VPNs can also be used for Site to Site connections, allowing for a number of VPCs across multiple cloud vendors to be linked in a secure manner. Depending on the configuration the connection between networks will appear seamless to the resources and assets within these networks, and this can operate in tandem with management systems such as CloudForms to ensure true cooperative multi-cloud workloads.

6.2.5 Combining SDN, Ansible, CloudForms for a Multi-cloud PI Scenario

Returning to the example in Figure 20 above but focussing on the IoT data streams and processing elements we can examine the creation and configuration of the multi-cloud approach needed. We can break the setup into some distinct steps the first of which mirrors the PoC environment creation and configuration. This entails creating the VPC and associated network functions and configuring them, deploying the services and then configuring access through public interfaces and VPNs. Ansible playbooks already exist for many of these steps, but some do not and will need to be written. However, this is not complex, as Code Snippet 1 below shows.

```
- name: crea e VPC
  ec2_ pc_ne :
    name: "    pc_name    "
    cidr_block: "    pc_cidr    "
    region: "   region    "
      a e: pre en
    a  _acce   _ke : "   a  _acce   _ke    "
    a  _ ecre _ke : "   a  _ ecre _ke    "
  regi  er:  pc
```

Code Snippet 1 - Ansible VPC Example

Ansible uses the AWS API to create the VPC as configured, the user does not have to use the API themselves, simplifying the approach significantly. Other systems and deployments are created and configured using similar approaches to above. CloudForms allows for the creation and maintenance of a catalogue of Ansible playbooks that will perform commonly required actions and can manage these in a centralised manner.

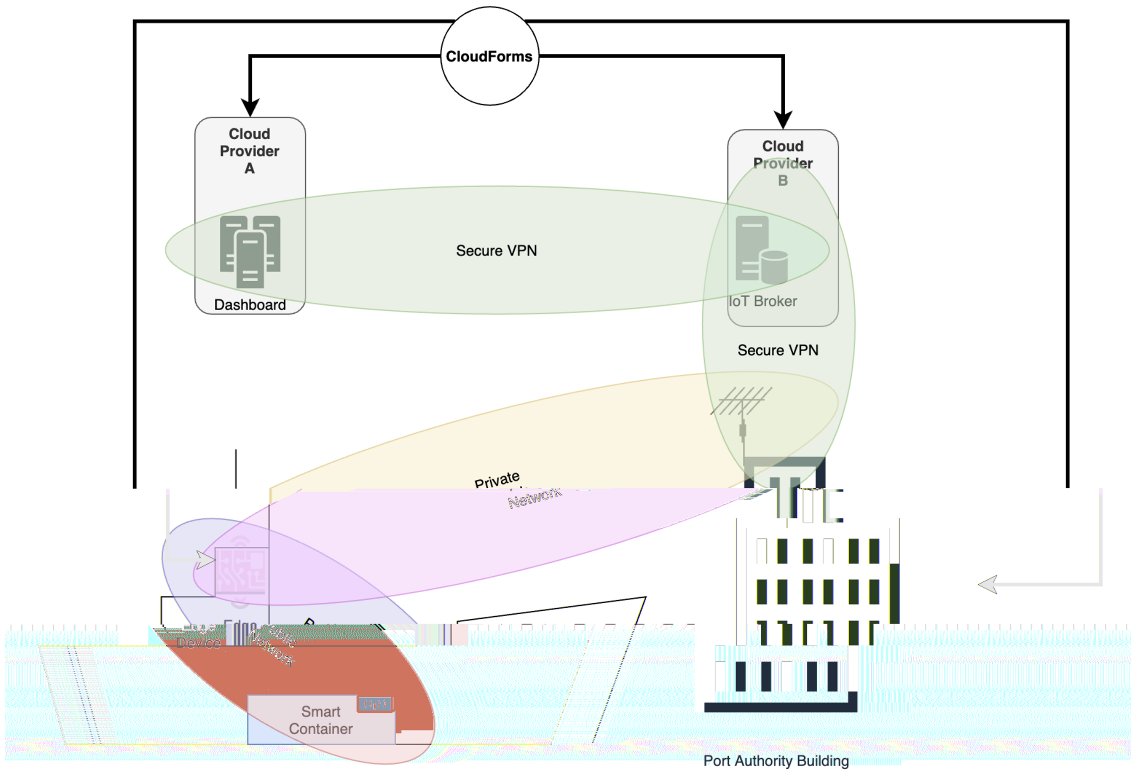


Figure 22 - Multi-cloud PI Network Scenario

Figure 22 shows the scenario from Figure 20 with a focus on the IoT data streams. In this scenario the IoT sensors in smart containers will connect to a local network if it exists – in this case the one on the ship. This connection is a public network, as all containers will connect to the same network. The network on the ship is maintained by an edge device which captures the sensor data for initial pre-processing, analysis or curation. This data can be forwarded via a private network through local connectivity (for example the port authority). This is a private network as the edge devices will only communicate with port authority networks through prior arrangement. The IoT data is forwarded to cloud provider B, chosen for their competitive rates for IoT brokerage. This is done via a secure VPN and finally the data can be accessed and visualised by an application deployed in Cloud Provider A as they have competitive rates for simple front-end application hosting. Both cloud provider networks are joined by a VPN also. CloudForms manages each entity through its own independent interface, and each of the 4 networks were created and are managed by CloudForms (using Ansible) but are used as communication pathways between cloud environments.

7 PoC Integration Environment Blueprint – Full Context

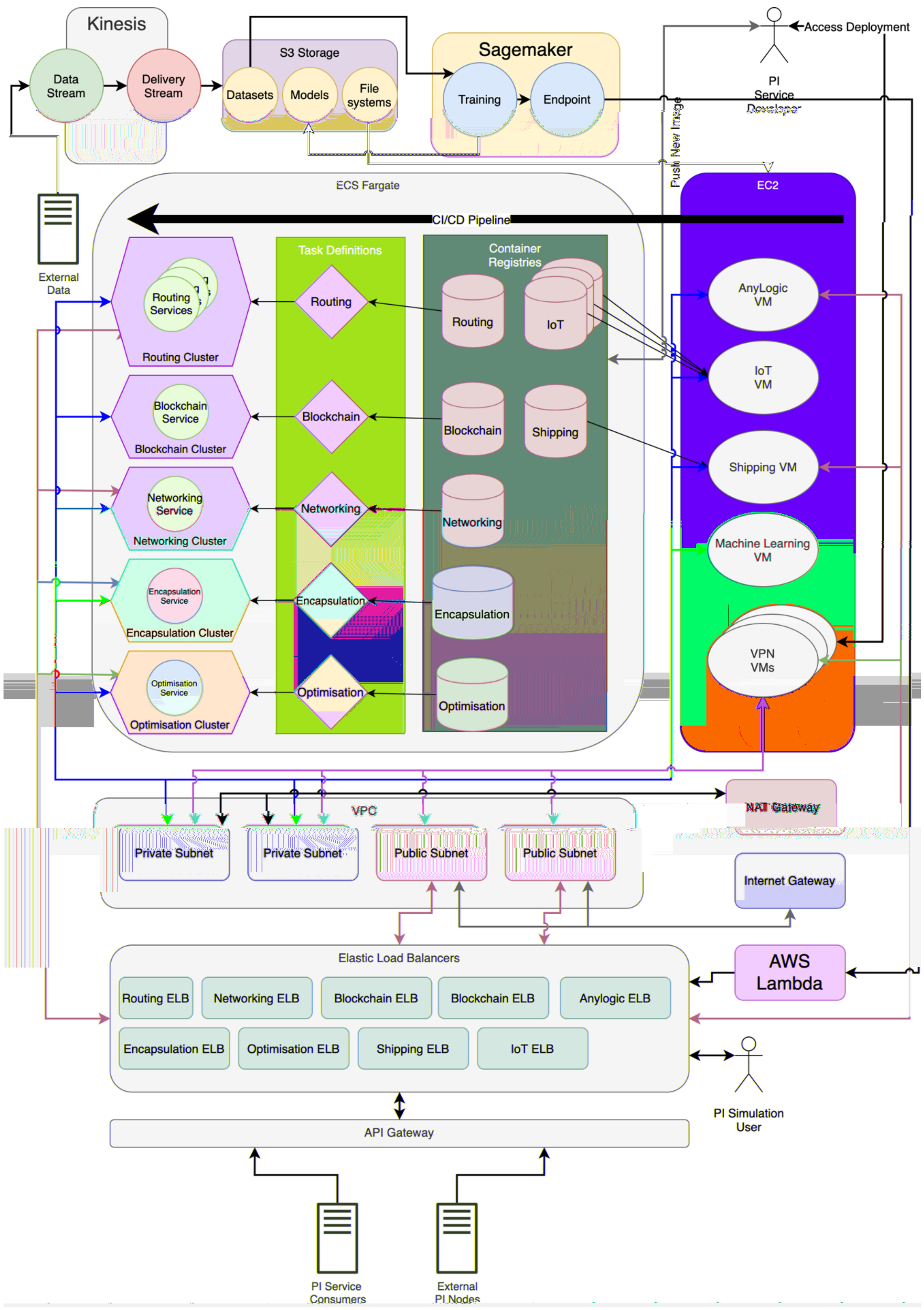


Figure 23 - PoC Blueprint

Figure 23 captures the technical components and component relationships in the PoC Integration Environment in the full context of versions one, two and three of this deliverable in a single diagram. All major technical assets (some elements were left out for clarity of the diagram) and services are represented in Figure 23 but have also been addressed and discussed in detail in the three documents. Figure 23 serves to show the “bigger picture” of how all the technical approaches and systems come together to form the PoC Integration Platform.

D2.19 (Version one) discussed:

- Based on the DoA, Defining Goals & Function of the PoC Environment
- The merits of PaaS as a service
- The approach for choosing a cloud vendor
- The variables and constraints needing consideration for the choice of cloud vendor
- Cloud vendor choice made & justifications for that choice
- Initial PoC Environment creation steps
- Potential Connectivity Scenarios for the PoC Environment

The outputs of that deliverable manifest in Figure 23 and this document by the choice of AWS as the cloud vendor, the substantial use of PaaS systems in the PoC, the external connectivity points to developers, external systems, external PI Nodes, and simulation users. Furthermore, the initial goes as set out in section 3.1 of D2.19 were addressed successfully as shown in Table 1 mapping the goals from D2.19 to the achievements as seen in D2.21.

Table 1: PoC Integration Platform Goals

	PoC Integration Platform Goals (D2.19, 3.1, Table 2)	Goals Addressed
1	Support the research and development efforts in WP2 by providing any tools, frameworks, network connectivity, user access and IaaS/PaaS infrastructure as required.	User access and secure connectivity provided, security policies created, code repositories created for source-controlled development
2	Provide an integration platform upon which PI services can be developed, deployed and tested.	All PI Services were deployed, tested and redeployed with subsequent versions within the PoC environment, with increasing use of automation as the project progressed
3	Support the interconnectivity between the PI services. Ensure that all communication ports and protocols are supported and implemented as needed by the technical requirements of the project.	VPCs, subnets, routing tables and firewall policies ensured that all PI Services communicated with each other and the simulation service in a controlled secure environment. When required, specific access was granted externally via load balancers facilitating Living Lab partners access, external PI Node access, simulation user access.

5	Provide integrated and controlled remote user access to PoC integration platform.	Remote access for developers was provided via secure VPN to the VPC, console access via the AWS web UI, command line access via the AWS CLI tool.
6	The integration platform should be flexible and elastic when responding to the technical demands of the project.	The project facilitated and carried rapid and significant redesign based on the needs of the project and all requirements from the PI Service developers were met in a timely manner
7	The integration platform should always be available.	The PoC Integration platform experienced no outages or downtime during the course of the project.

D2.20 (Version two) discussed:

- Restating the goals of the PoC Integration Environment
- The interdependencies of the PI Architecture and the PoC Integration Environment
- Integration Strategies and practical approaches
- The main resource and services (such as compute and storage) that would support the PI Services & other services within the PoC environment.
- Deployment methods and approaches
- Reports on initial assets deployed
- Reports on pilot integrations
- Report on Simulation Service Deployment
- PI Services Dataflow

The outputs of D2.20 can be identified in Figure 23 by noting the integrations and data flows across multiple PI Services, simulations, external actors, data sources and external systems. In addition, compute and storage systems such as S3, Fargate, ECS and EC2 play a central role in the deployment PI Services and other services.

D2.21 (Version three & this document) discusses:

- More complex integration structures such as
  - Elastic Load Balancers
  - Static Addresses
  - Public Access to PI Service APIs
  - API Gateways, authentication and security
  - Deployment pipelines
  - Machine Learning
    - Data acquisition
    - Training
    - Model management
    - API Gateways & AWS Lambda
    - Machine learning based APIs

The outputs of this document, D2.21, can be identified in Figure 23 by noting the deployment pipeline across all ECS systems and deployed services, the load balancers that serve as public interfaces to PI Services where legacy systems, external PI nods and testing and evaluation can take place, the API gateway that fronts these load balancers for authentication purposes and their relationship to existing SDN structures such as public and private subnets in the VPC and NAT and Internet Gateways. In addition the machine learning pipeline can be identified near the top of the diagram showing data acquisition, model training and storage and finally AWS lambda and API Gateways to allow machine learning services to be available using PaaS.

8 Conclusion

The research and technical implementations undertaken for these deliverables and tasks have successfully met the current needs of the ICONET project. In addition, this document has begun to address the needs of future PI engagements including anything from further research, to pilot PI programs to full production level PI engagements. The containerisation approach is considered vastly superior to other approaches for service development due to the homogenous nature of development work and flexibility provided. Containerisation allows for a reusable series of deployment requirements across all PI Services. The PI Services stack clearly aligns with the current trend in microservices based architectures which allows the PI Services to benefit from orchestration technologies and emerging serverless compute approaches.

The use of PaaS as the supporting cloud and deployment frameworks in conjunction with containerisation and microservices approaches matched well with the PI Service stack and should be an approach that is followed for future PI research efforts. By limiting containerised services to core PI Service functionality this both offloads non-functional requirements away from PI Service developers, but also allows for a unified approach to non-functional issues (security, deployment etc.). Given emerging trends in cloud technology, the ability for all services to be centrally supported and integrated across multiple cloud vendors is critical.

The use of machine learning technologies is recognised to be an approach that will be extensively adopted in the PI and logistics domain given the huge benefits that could be derived from it. Strategies and technologies such as robust data streams, cloud side pre-processing, the use of PaaS systems, service mesh, and CI/CD pipeline integrations must be adopted to make efficient use of these technologies in harmony with existing technological approaches.

The newest trend in cloud computing paradigms is to adopt a multi-cloud or hybrid cloud approach seeing workloads spread across any number of private and public clouds across a number of technology providers. Given the diverse array of actors, assets and systems in a PI scenario it is likely the bleeding edge of the PI will intersect with the bleeding edge of cloud computing. It is critical to understand these trends now, adopt technologies and practices early to integrate these two concepts to encourage PI adoption at the greatest possible rate. Emerging paradigms such as multi-cloud and fog computing will change how organisations approach their IT solutions, and not only will the PI adapt to these paradigms, but it will excel because of them.

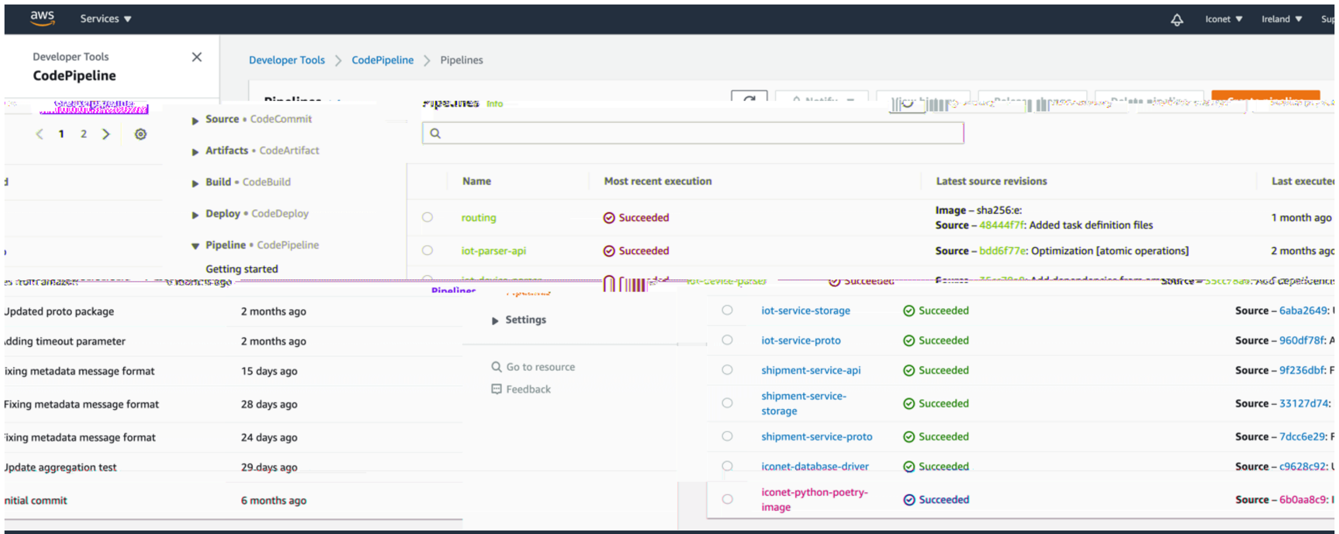
The PoC Integration task and associated deliverables aimed to provide a strategy for collaborative research as well as a technological approach to facilitate research and integration for PI Services and other assets. The PoC platform supported research in the PI domain, aided in evolving the PI reference architecture, development of PI services, supported deployment and integration of all PI Services and simulation services and provided practical approaches for the present as well as state of the art approaches for the future which will ensure the PI Services meet both functional and non-functional requirements.

Annex I – Accessing the PoC Environment for Evaluation

Any authorised party outside the consortium who wishes to access the PoC integration environment hosted in AWS can do so by making contact with ILS, the project coordinator, to arrange secure access via VPN or AWS login credentials. Anyone accessing the PoC environment will need some dev-ops or cloud computing skills to successfully navigate the assets, services and systems within as this is technical platform not designed for end users.

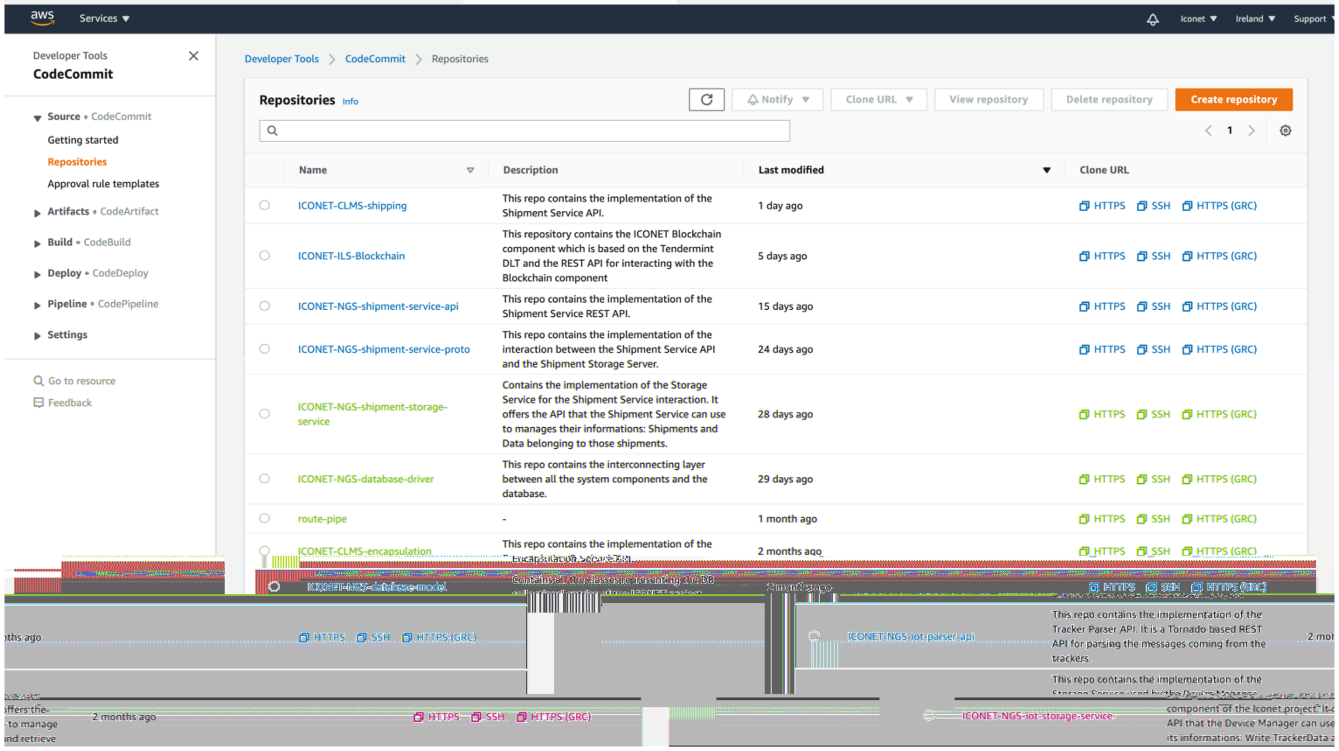
The Anylogic Simulation service can be accessed from a browser at http://172.31.6.36/auth/login . Access requires a login name and password which INV will provide and this interface does not require an IT, dev-ops or cloud engineering background.

Annex II –PoC Integration Environment Screenshots

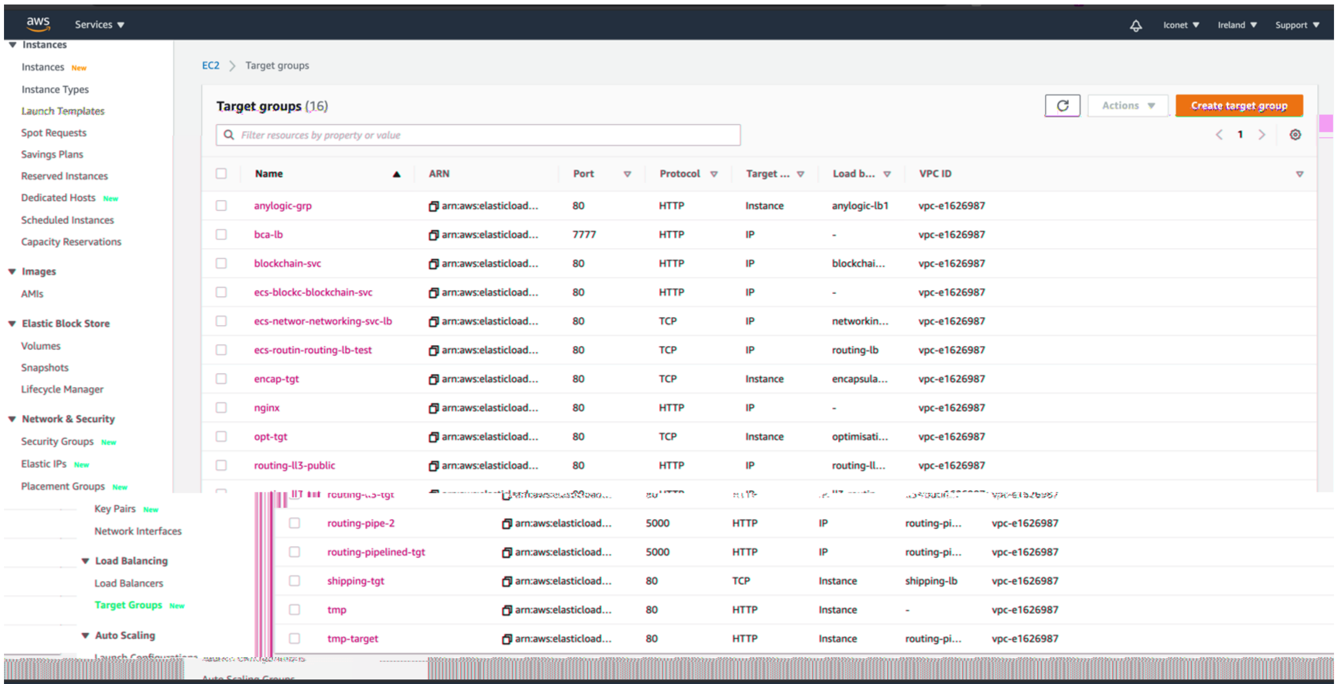


	Name	Most recent execution	Latest source revisions	Last executed
○	routing	Succeeded	Image – sha256:e: Source – 48444f7f: Added task definition files	1 month ago
○	iot-parser-api	Succeeded	Source – bdd6f77e: Optimization [atomic operations]	2 months ago
○	iot-service-storage	Succeeded	Source – 6aba2649:	
○	iot-service-proto	Succeeded	Source – 960df78f:	
○	shipment-service-api	Succeeded	Source – 9f236dbf:	
○	shipment-service-storage	Succeeded	Source – 33127d74:	
○	shipment-service-proto	Succeeded	Source – 7dcc6e29:	
○	iconet-database-driver	Succeeded	Source – c9628c92:	
○	iconet-python-poetry-image	Succeeded	Source – 6b0aa8c9:	

Updated proto package	2 months ago
Adding timeout parameter	2 months ago
Fixing metadata message format	15 days ago
Fixing metadata message format	28 days ago
Fixing metadata message format	24 days ago
Update aggregation test	29 days ago
Initial commit	6 months ago



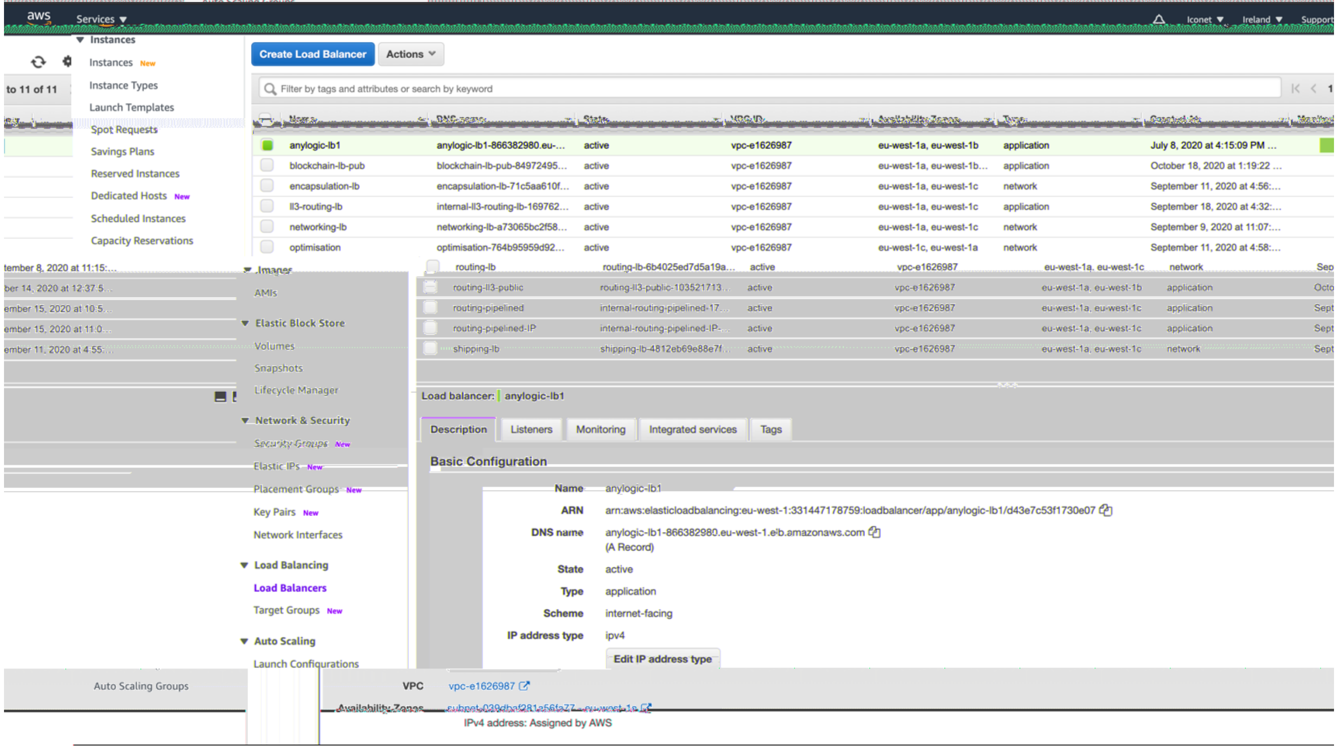
	Name	Description	Last modified	Clone URL
○	ICONET-CLMS-shipping	This repo contains the implementation of the Shipment Service API.	1 day ago	HTTPS SSH HTTPS (GRC)
○	ICONET-ILS-Blockchain	This repository contains the ICONET Blockchain component which is based on the Tendermint DLT and the REST API for interacting with the Blockchain component	5 days ago	HTTPS SSH HTTPS (GRC)
○	ICONET-NGS-shipment-service-api	This repo contains the implementation of the Shipment Service REST API.	15 days ago	HTTPS SSH HTTPS (GRC)
○	ICONET-NGS-shipment-service-proto	This repo contains the implementation of the interaction between the Shipment Service API and the Shipment Storage Server.	24 days ago	HTTPS SSH HTTPS (GRC)
○	ICONET-NGS-shipment-storage-service	Contains the implementation of the Storage Service for the Shipment Service interaction. It offers the API that the Shipment Service can use to manages their informations: Shipments and Data belonging to those shipments.	28 days ago	HTTPS SSH HTTPS (GRC)
○	ICONET-NGS-database-driver	This repo contains the interconnecting layer between all the system components and the database.	29 days ago	HTTPS SSH HTTPS (GRC)
○	route-pipe	-	1 month ago	HTTPS SSH HTTPS (GRC)
○	ICONET-CLMS-encapsulation	This repo contains the implementation of the Encapsulation Service API.	2 months ago	HTTPS SSH HTTPS (GRC)
○	ICONET-NGS-database-model	Contains all the classes representing the DB	2 months ago	HTTPS SSH HTTPS (GRC)
○	ICONET-NGS-iot-parser-api	This repo contains the implementation of the Tracker Parser API. It is a Tornado based REST API for parsing the messages coming from the trackers.	2 months ago	
○	ICONET-NGS-iot-storage-service	This repo contains the implementation of the Storage Service used by the Device Manager component of the Iconet project. It offers the API that the Device Manager can use to manage its informations: Write TrackerData and retrieve	2 months ago	HTTPS SSH HTTPS (GRC)



EC2 > Target groups

Target groups (16)

Name	ARN	Port	Protocol	Target ...	Load b...	VPC ID
anylogic-grp	arn:aws:elasticload...	80	HTTP	Instance	anylogic-lb1	vpc-e1626987
bca-lb	arn:aws:elasticload...	7777	HTTP	IP	-	vpc-e1626987
blockchain-svc	arn:aws:elasticload...	80	HTTP	IP	blockchai...	vpc-e1626987
ecs-blockc-blockchain-svc	arn:aws:elasticload...	80	HTTP	IP	-	vpc-e1626987
ecs-networ-networking-svc-lb	arn:aws:elasticload...	80	TCP	IP	networkin...	vpc-e1626987
ecs-routin-routing-lb-test	arn:aws:elasticload...	80	TCP	IP	routing-lb	vpc-e1626987
encap-tgt	arn:aws:elasticload...	80	TCP	Instance	encapsula...	vpc-e1626987
nginx	arn:aws:elasticload...	80	HTTP	IP	-	vpc-e1626987
opt-tgt	arn:aws:elasticload...	80	TCP	Instance	optimisati...	vpc-e1626987
routing-ll3-public	arn:aws:elasticload...	80	HTTP	IP	routing-ll...	vpc-e1626987
routing-ll3-tgt	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	vpc-e1626987
routing-pipe-2	arn:aws:elasticload...	5000	HTTP	IP	routing-pi...	vpc-e1626987
routing-pipelined-tgt	arn:aws:elasticload...	5000	HTTP	IP	routing-pi...	vpc-e1626987
shipping-tgt	arn:aws:elasticload...	80	TCP	Instance	shipping-lb	vpc-e1626987
tmp	arn:aws:elasticload...	80	HTTP	Instance	-	vpc-e1626987
tmp-target	arn:aws:elasticload...	80	HTTP	Instance	routing-pi...	vpc-e1626987

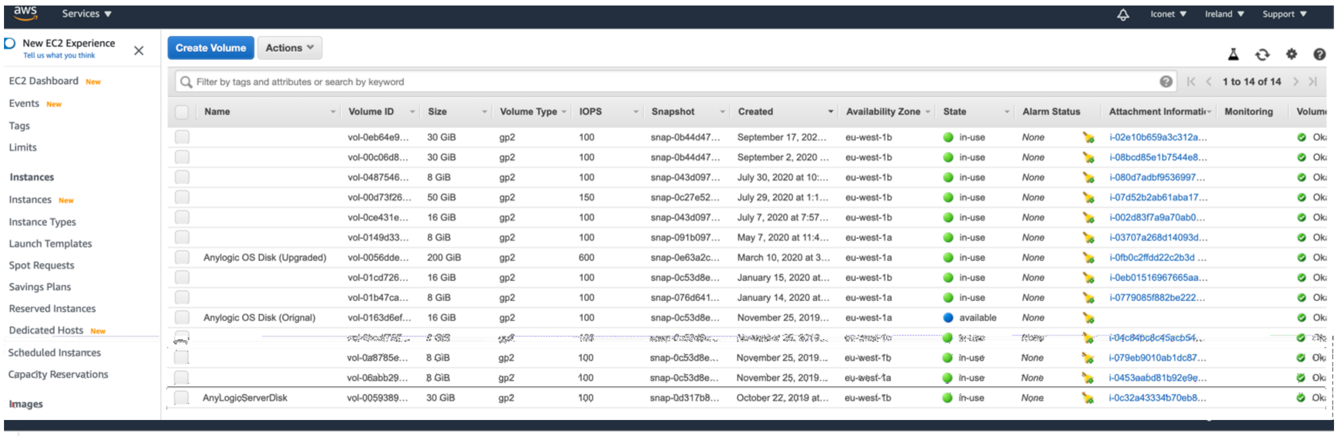


Name	DNS name	State	VPC ID	Availability Zones	Type	Created At
anylogic-lb1	anylogic-lb1-866382980.eu-...	active	vpc-e1626987	eu-west-1a, eu-west-1b	application	July 8, 2020 at 4:15:09 PM ...
blockchain-lb-pub	blockchain-lb-pub-84972495...	active	vpc-e1626987	eu-west-1a, eu-west-1b...	application	October 18, 2020 at 1:19:22 ...
encapsulation-lb	encapsulation-lb-71c5aa610f...	active	vpc-e1626987	eu-west-1a, eu-west-1c	network	September 11, 2020 at 4:56:...
ll3-routing-lb	internal-ll3-routing-lb-169762...	active	vpc-e1626987	eu-west-1a, eu-west-1c	application	September 18, 2020 at 4:32:...
networking-lb	networking-lb-a73065bc2f58...	active	vpc-e1626987	eu-west-1a, eu-west-1c	network	September 9, 2020 at 11:07:...
optimisation	optimisation-764b95959d92...	active	vpc-e1626987	eu-west-1c, eu-west-1a	network	September 11, 2020 at 4:58:...
routing-lb	routing-lb-6b4025ed7d5a19a...	active	vpc-e1626987	eu-west-1a, eu-west-1c	network	Sep
routing-ll3-public	routing-ll3-public-103521713...	active	vpc-e1626987	eu-west-1a, eu-west-1b	application	Octo
routing-pipelined	internal-routing-pipelined-17...	active	vpc-e1626987	eu-west-1a, eu-west-1c	application	Sept
routing-pipelined-IP	internal-routing-pipelined-IP-...	active	vpc-e1626987	eu-west-1a, eu-west-1c	application	Sept
shipping-lb	shipping-lb-4812eb69e88e7f...	active	vpc-e1626987	eu-west-1a, eu-west-1c	network	Sept

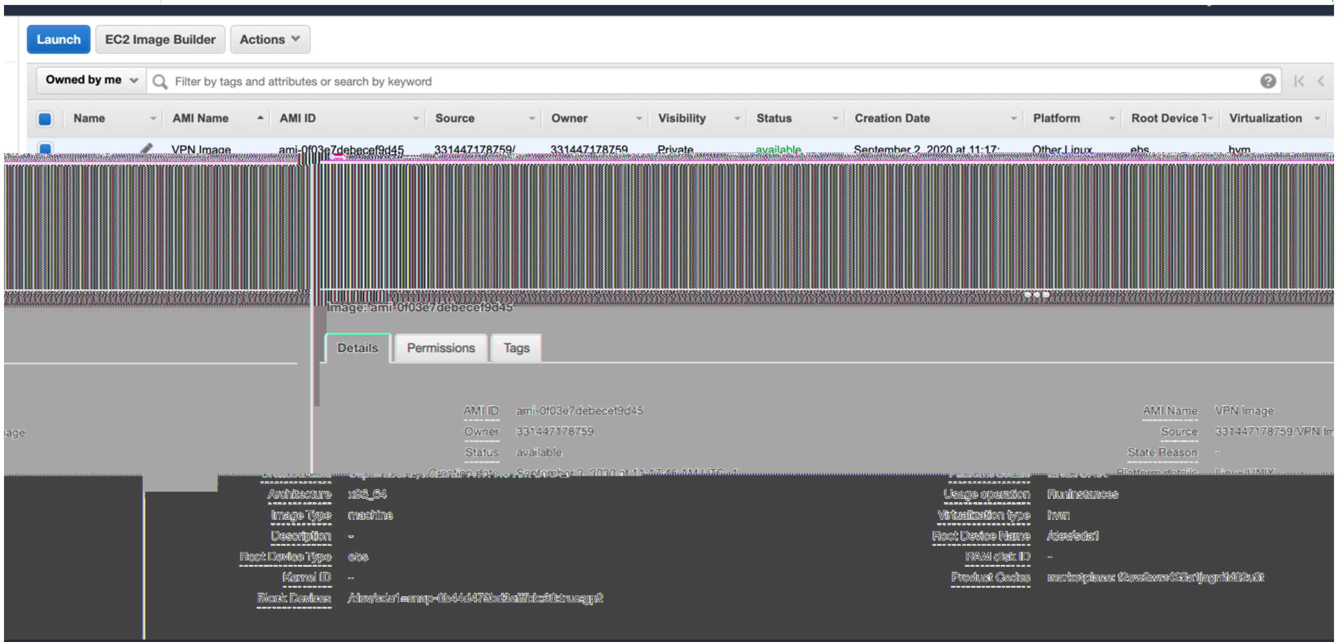
Load balancer: anylogic-lb1

Basic Configuration

Name	anylogic-lb1
ARN	arn:aws:elasticloadbalancing:eu-west-1:331447178759:loadbalancer/app/anylogic-lb1/d43e7c53f1730e07
DNS name	anylogic-lb1-866382980.eu-west-1.elb.amazonaws.com (A Record)
State	active
Type	application
Scheme	internet-facing
IP address type	ipv4
VPC	vpc-e1626987
Availability Zones	subnet-039dbaf281a56fa77 - eu-west-1a IPv4 address: Assigned by AWS



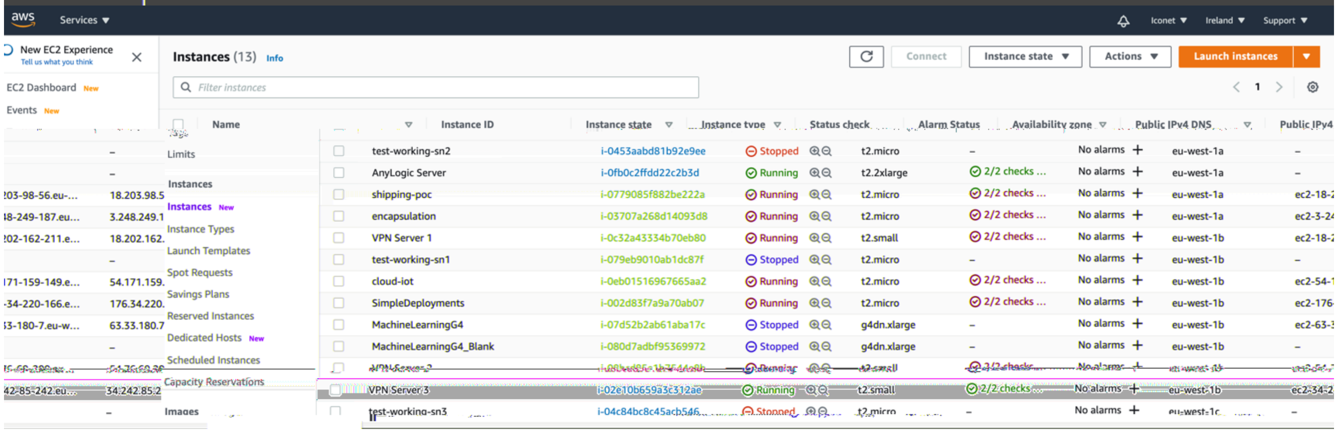
Name	Volume ID	Size	Volume Type	IOPS	Snapshot	Created	Availability Zone	State	Alarm Status	Attachment Informati	Monitoring	Volum
	vol-0eb64e9...	30 GiB	gp2	100	snap-0b44d47...	September 17, 202...	eu-west-1b	in-use	None	i-02e10b659a3c312a...		Oka
	vol-00c06d8...	30 GiB	gp2	100	snap-0b44d47...	September 2, 2020 ...	eu-west-1b	in-use	None	i-08bcd85e1b7544e8...		Oka
	vol-0487546...	8 GiB	gp2	100	snap-043d097...	July 30, 2020 at 10:...	eu-west-1b	in-use	None	i-080d7adbf9536997...		Oka
	vol-00d73f26...	50 GiB	gp2	150	snap-0c27e52...	July 29, 2020 at 1:1...	eu-west-1b	in-use	None	i-07d52b2ab61aba17...		Oka
	vol-0ce431e...	16 GiB	gp2	100	snap-043d097...	July 7, 2020 at 7:57...	eu-west-1b	in-use	None	i-002d83f7a9a70ab0...		Oka
	vol-0149d33...	8 GiB	gp2	100	snap-091b097...	May 7, 2020 at 11:4...	eu-west-1a	in-use	None	i-03707a268d14093d...		Oka
Anylogic OS Disk (Upgraded)	vol-0056dde...	200 GiB	gp2	600	snap-0e63a2c...	March 10, 2020 at 3...	eu-west-1a	in-use	None	i-0fb0c2ffdd22c2b3d ...		Oka
	vol-01cd726...	16 GiB	gp2	100	snap-0c53d8e...	January 15, 2020 at...	eu-west-1b	in-use	None	i-0eb01516967665aa...		Oka
	vol-01b47ca...	8 GiB	gp2	100	snap-076d641...	January 14, 2020 at...	eu-west-1a	in-use	None	i-0779085f882be222...		Oka
Anylogic OS Disk (Orignal)	vol-0163d6ef...	16 GiB	gp2	100	snap-0c53d8e...	November 25, 2019...	eu-west-1a	available	None			Oka
	[illegible]	8 GiB	gp2	100	[illegible]	November 25, 2019...	[illegible]	in-use	None	i-04c84bc8c45acb54...		[illegible]
	vol-0a8785e...	8 GiB	gp2	100	snap-0c53d8e...	November 25, 2019...	eu-west-1b	in-use	None	i-079eb9010ab1dc87...		Oka
	vol-06abb29...	8 GiB	gp2	100	snap-0c53d8e...	November 25, 2019...	eu-west-1a	in-use	None	i-0453aabd81b92e9e...		Oka
AnyLogicServerDisk	vol-0059389...	30 GiB	gp2	100	snap-0d317b8...	October 22, 2019 at...	eu-west-1b	in-use	None	i-0c32a43334b70eb8...		Oka



Name	AMI Name	AMI ID	Source	Owner	Visibility	Status	Creation Date	Platform	Root Device T	Virtualization
	VPN Image	ami-0f03e7debecef9d45	331447178759/	331447178759	Private	available	September 2, 2020 at 11:17:	Other Linux	ebs	hvm

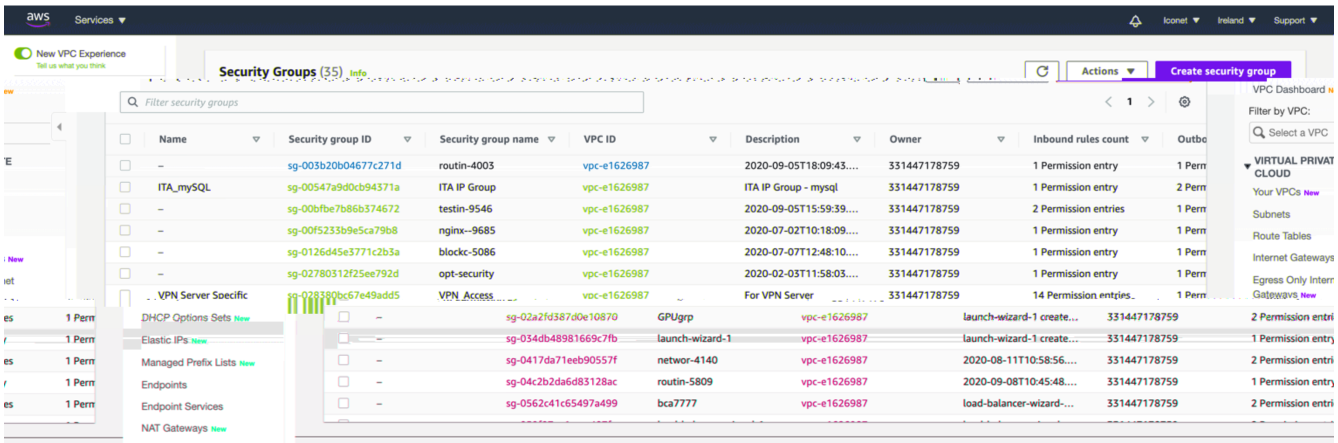
Image: ami-0f03e7debecef9d45

AMI ID	ami-0f03e7debecef9d45	AMI Name	VPN Image
Owner	331447178759	Source	331447178759/VPN Im
Status	available	State Reason	-
Creation date	September 2, 2020 at 11:17:46 AM UTC+1	Platform details	Linux/UNIX
Architecture	x86_64	Usage operation	RunInstances
Image Type	machine	Virtualization type	hvm
Description	-	Root Device Name	/dev/sda1
Root Device Type	ebs	RAM disk ID	-
Kernel ID	-	Product Codes	marketplace: f2ew2wrz425a1jagnifd02u5t
Block Devices	/dev/sda1=snap-0b44d479bd3efffbb:30:true:gp2		



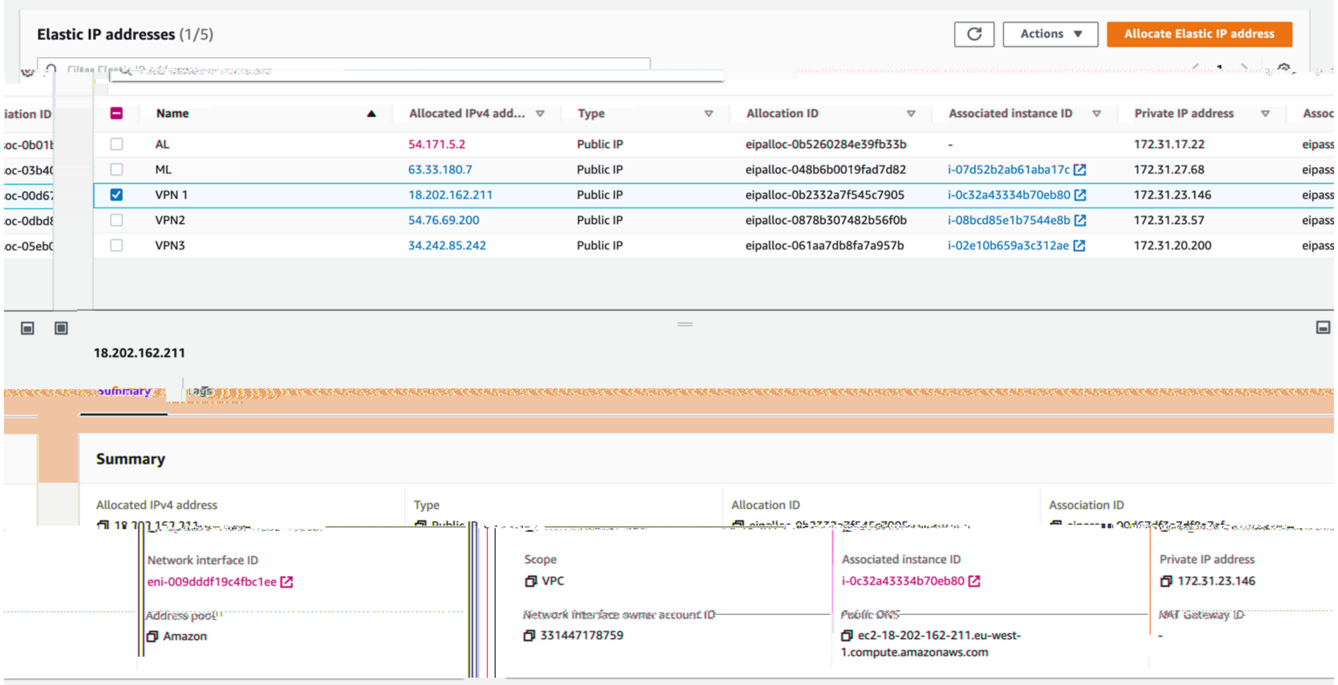
Instances (13) Info

Name	Instance ID	Instance state	Instance type	Status check	Alarm Status	Availability zone	Public IPv4 DNS	Public IPv4
test-working-sn2	i-0453aabd81b92e9ee	Stopped	t2.micro	–	No alarms	eu-west-1a	–	–
AnyLogic Server	i-0fb0c2ffdd22c2b3d	Running	t2.2xlarge	2/2 checks ...	No alarms	eu-west-1a	–	–
shipping-poc	i-0779085f882be222a	Running	t2.micro	2/2 checks ...	No alarms	eu-west-1a	ec2-18-2 … 203-98-56.eu-...	18.203.98.5
encapsulation	i-03707a268d14093d8	Running	t2.micro	2/2 checks ...	No alarms	eu-west-1a	ec2-3-24 … 8-249-187.eu...	3.248.249.1
VPN Server 1	i-0c32a43334b70eb80	Running	t2.small	2/2 checks ...	No alarms	eu-west-1b	ec2-18-2 … 202-162-211.e...	18.202.162.
test-working-sn1	i-079eb9010ab1dc87f	Stopped	t2.micro	–	No alarms	eu-west-1b	–	–
cloud-iot	i-0eb01516967665aa2	Running	t2.micro	2/2 checks ...	No alarms	eu-west-1b	ec2-54-1 … 171-159-149.e...	54.171.159.
SimpleDeployments	i-002d83f7a9a70ab07	Running	t2.micro	2/2 checks ...	No alarms	eu-west-1b	ec2-176- … -34-220-166.e...	176.34.220.
MachineLearningG4	i-07d52b2ab61aba17c	Stopped	g4dn.xlarge	–	No alarms	eu-west-1b	ec2-63-3 … 3-180-7.eu-w...	63.33.180.7
MachineLearningG4_Blank	i-080d7adbf95369972	Stopped	g4dn.xlarge	–	No alarms	eu-west-1b	–	–
VPN Server 2	[illegible]	Running	t2.small	2/2 checks ...	No alarms	eu-west-1b	[illegible]	[illegible]
VPN Server 3	i-02e10b659a3c312ae	Running	t2.small	2/2 checks ...	No alarms	eu-west-1b	ec2-34-2 … 42-85-242.eu...	34.242.85.2
test-working-sn3	i-04c84bc8c45acb546	Stopped	t2.micro	–	No alarms	eu-west-1c	–	–



Security Groups (35) Info

Name	Security group ID	Security group name	VPC ID	Description	Owner	Inbound rules count	Outbo
–	sg-003b20b04677c271d	routin-4003	vpc-e1626987	2020-09-05T18:09:43....	331447178759	1 Permission entry	1 Perm
ITA_mySQL	sg-00547a9d0cb94371a	ITA IP Group	vpc-e1626987	ITA IP Group - mysql	331447178759	1 Permission entry	2 Perm
–	sg-00bfbe7b86b374672	testin-9546	vpc-e1626987	2020-09-05T15:59:39....	331447178759	2 Permission entries	1 Perm
–	sg-00f5233b9e5ca79b8	nginx--9685	vpc-e1626987	2020-07-02T10:18:09....	331447178759	1 Permission entry	1 Perm
–	sg-0126d45e3771c2b3a	blockc-5086	vpc-e1626987	2020-07-07T12:48:10....	331447178759	1 Permission entry	1 Perm
–	sg-02780312f25ee792d	opt-security	vpc-e1626987	2020-02-03T11:58:03....	331447178759	1 Permission entry	1 Perm
VPN Server Specific	sg-028380bc67e49add5	VPN Access	vpc-e1626987	For VPN Server	331447178759	14 Permission entries	1 Perm
–	sg-02a2fd387d0e10870	GPUgrp	vpc-e1626987	launch-wizard-1 create...	331447178759	2 Permission entri	
–	sg-034db48981669c7fb	launch-wizard-1	vpc-e1626987	launch-wizard-1 create...	331447178759	1 Permission entry	
–	sg-0417da71eeb90557f	networ-4140	vpc-e1626987	2020-08-11T10:58:56....	331447178759	2 Permission entri	
–	sg-04c2b2da6d83128ac	routin-5809	vpc-e1626987	2020-09-08T10:45:48....	331447178759	1 Permission entry	
–	sg-0562c41c65497a499	bca7777	vpc-e1626987	load-balancer-wizard-...	331447178759	2 Permission entri	



Elastic IP addresses (1/5)

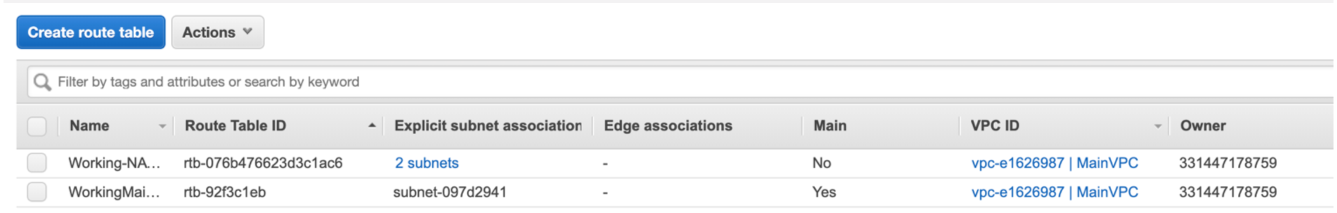
iation ID		Name	Allocated IPv4 add...	Type	Allocation ID	Associated instance ID	Private IP address	Assoc
oc-0b01t	☐	AL	54.171.5.2	Public IP	eipalloc-0b5260284e39fb33b	-	172.31.17.22	eipass
oc-03b4(	☐	ML	63.33.180.7	Public IP	eipalloc-048b6b0019fad7d82	i-07d52b2ab61aba17c	172.31.27.68	eipass
oc-00d67	✓	VPN 1	18.202.162.211	Public IP	eipalloc-0b2332a7f545c7905	i-0c32a43334b70eb80	172.31.23.146	eipass
oc-0dbd8	☐	VPN2	54.76.69.200	Public IP	eipalloc-0878b307482b56f0b	i-08bcd85e1b7544e8b	172.31.23.57	eipass
oc-05eb(	☐	VPN3	34.242.85.242	Public IP	eipalloc-061aa7db8fa7a957b	i-02e10b659a3c312ae	172.31.20.200	eipass

18.202.162.211

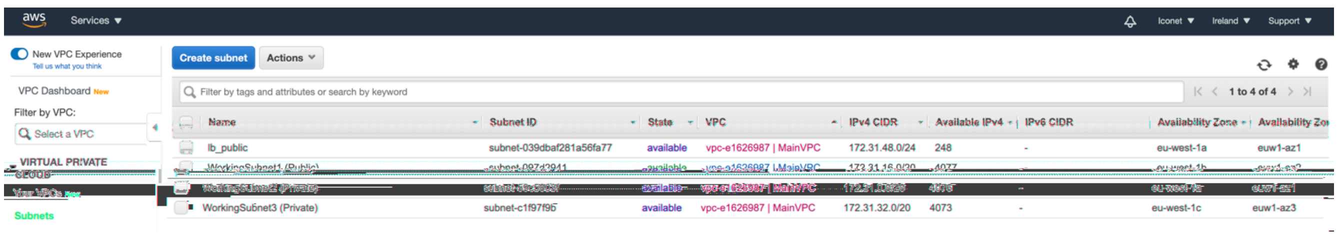
Summary

Allocated IPv4 address	Type	Allocation ID	Association ID
18.202.162.211	Public IP	[illegible]	[illegible]

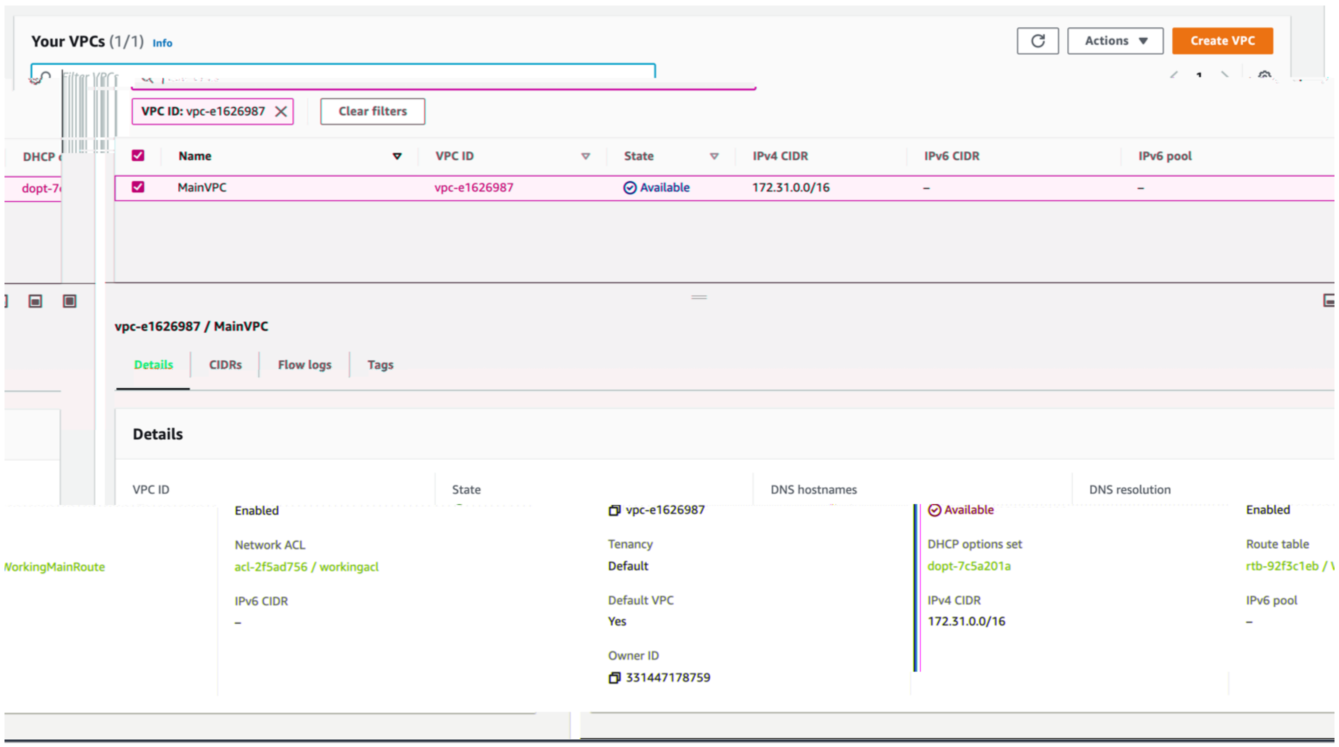
Network interface ID	Scope	Associated instance ID	Private IP address
eni-009dddf19c4fbc1ee	VPC	i-0c32a43334b70eb80	172.31.23.146
Address pool	**Network interface owner account ID**	**Public DNS**	**NAT Gateway ID**
Amazon	331447178759	ec2-18-202-162-211.eu-west-1.compute.amazonaws.com	-



	Name	Route Table ID	Explicit subnet association	Edge associations	Main	VPC ID	Owner
☐	Working-NA...	rtb-076b476623d3c1ac6	2 subnets	-	No	vpc-e1626987 | MainVPC	331447178759
☐	WorkingMai...	rtb-92f3c1eb	subnet-097d2941	-	Yes	vpc-e1626987 | MainVPC	331447178759



	Name	Subnet ID	State	VPC	IPv4 CIDR	Available IPv4	IPv6 CIDR	Availability Zone	Availability Zo
☐	lb_public	subnet-039dbaf281a56fa77	available	vpc-e1626987 | MainVPC	172.31.48.0/24	248	-	eu-west-1a	euw1-az1
☐	WorkingSubnet1 (Public)	subnet-097d2941	available	vpc-e1626987 | MainVPC	172.31.16.0/20	4077	-	eu-west-1b	euw1-az2
☐	WorkingSubnet2 (Private)	[illegible]	available	vpc-e1626987 | MainVPC	[illegible]	4076	-	eu-west-1a	euw1-az1
☐	WorkingSubnet3 (Private)	subnet-c1f97f9b	available	vpc-e1626987 | MainVPC	172.31.32.0/20	4073	-	eu-west-1c	euw1-az3

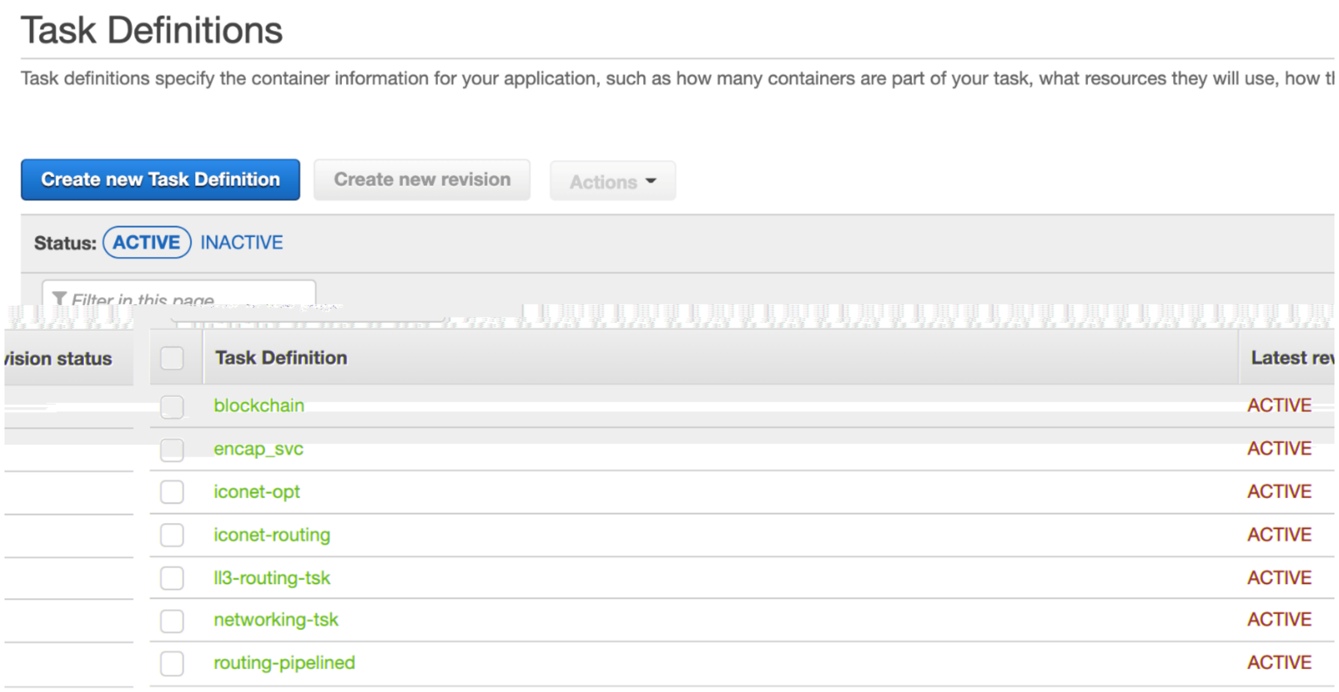


Name	VPC ID	State	IPv4 CIDR	IPv6 CIDR	IPv6 pool
MainVPC	vpc-e1626987	Available	172.31.0.0/16	–	–

vpc-e1626987 / MainVPC

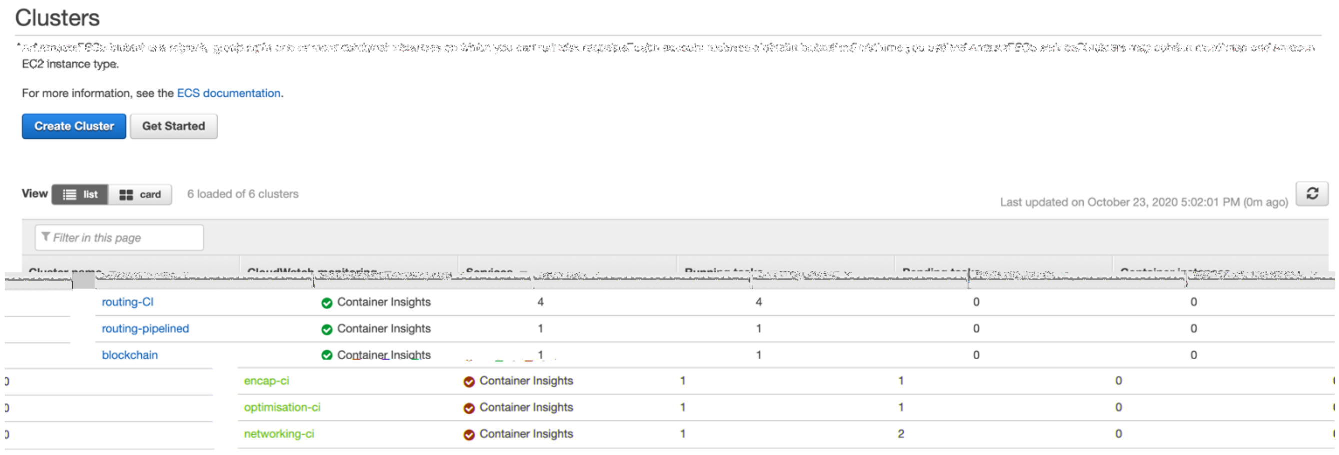
Details

VPC ID	State	DNS hostnames	DNS resolution
vpc-e1626987	Available	Enabled	Enabled
Tenancy	DHCP options set	Route table	Network ACL
Default	dopt-7c5a201a	rtb-92f3c1eb / WorkingMainRoute	acl-2f5ad756 / workingacl
Default VPC	IPv4 CIDR	IPv6 pool	IPv6 CIDR
Yes	172.31.0.0/16	–	–
Owner ID			
331447178759			


Task Definitions

Task definitions specify the container information for your application, such as how many containers are part of your task, what resources they will use, how t

Task Definition	Latest revision status
blockchain	ACTIVE
encap_svc	ACTIVE
iconet-opt	ACTIVE
iconet-routing	ACTIVE
ll3-routing-tsk	ACTIVE
networking-tsk	ACTIVE
routing-pipelined	ACTIVE



Clusters

[illegible] EC2 instance type.

For more information, see the ECS documentation.

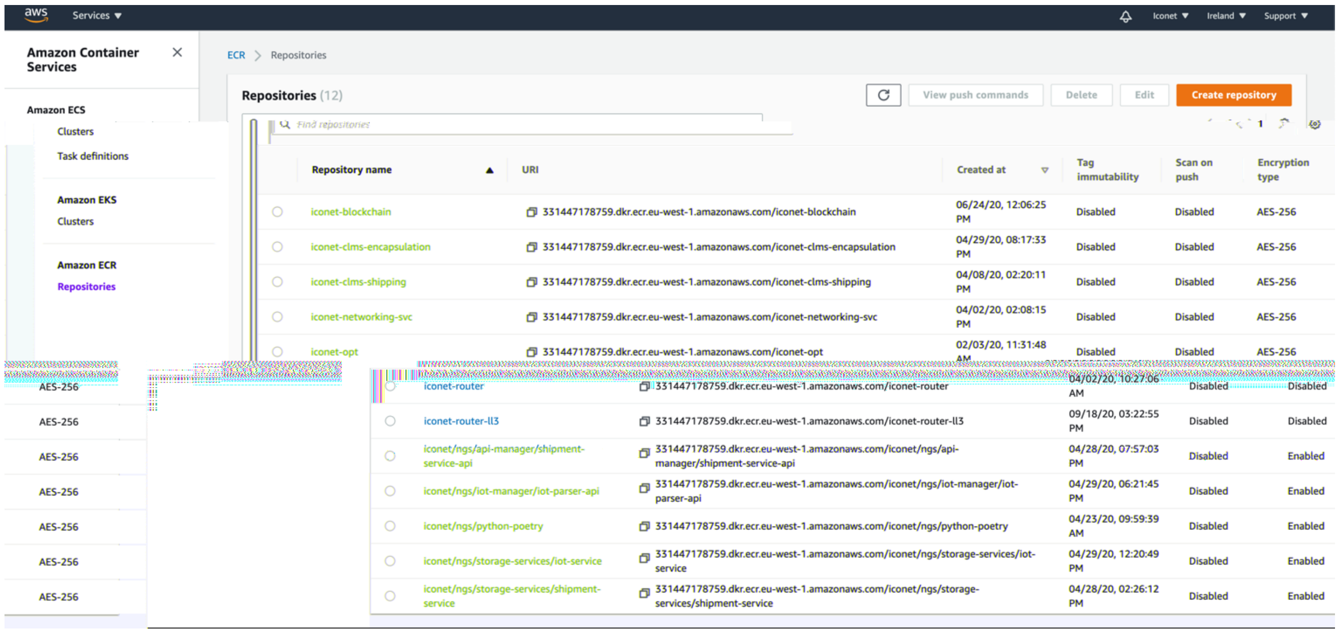
Create Cluster | Get Started

View list card 6 loaded of 6 clusters

Last updated on October 23, 2020 5:02:01 PM (0m ago)

Filter in this page

Cluster name	CloudWatch monitoring	Services	Running tasks	Pending tasks	Container instances
routing-CI	✓ Container Insights	4	4	0	0
routing-pipelined	✓ Container Insights	1	1	0	0
blockchain	✓ Container Insights	1	1	0	0
encap-ci	✓ Container Insights	1	1	0	
optimisation-ci	✓ Container Insights	1	1	0	
networking-ci	✓ Container Insights	1	2	0	



Amazon Container Services

Amazon ECS
- Clusters
- Task definitions

Amazon EKS
- Clusters

Amazon ECR
- Repositories

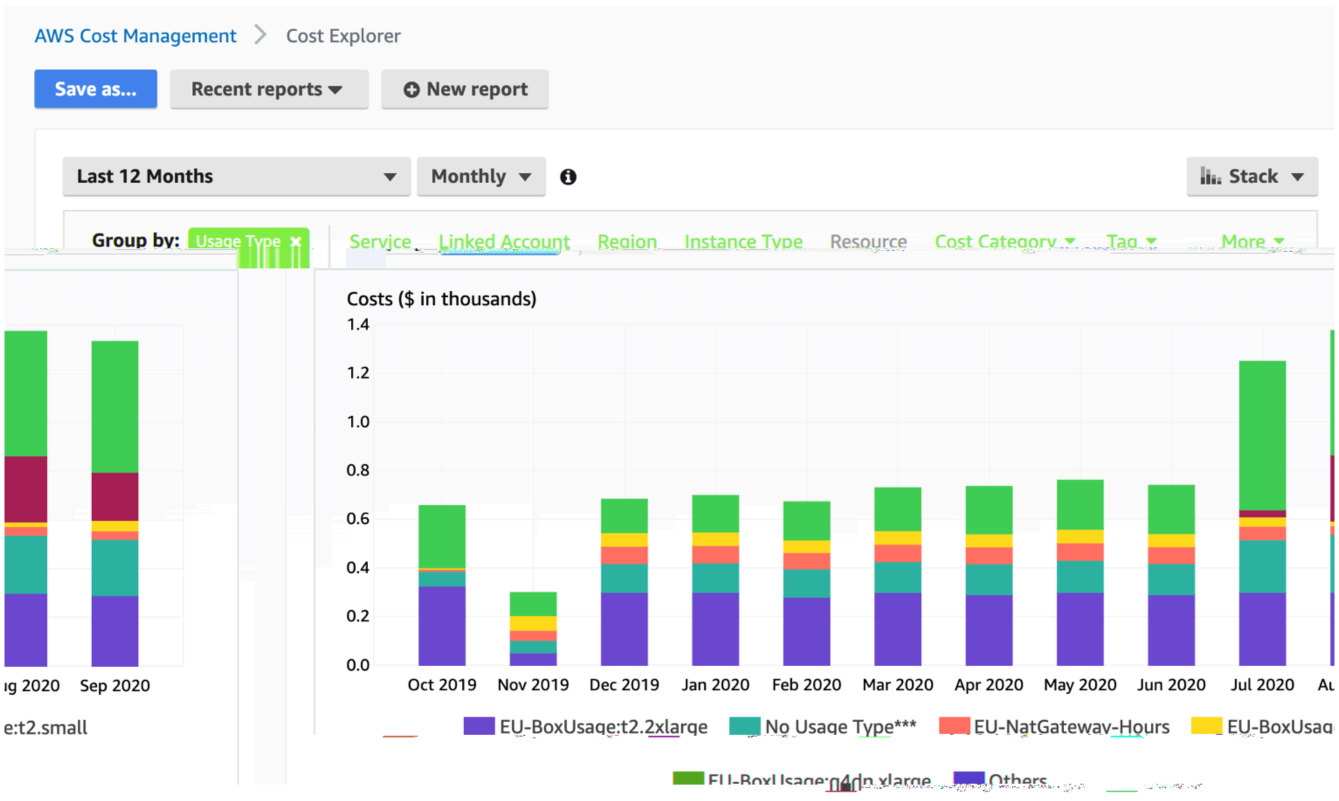
ECR > Repositories

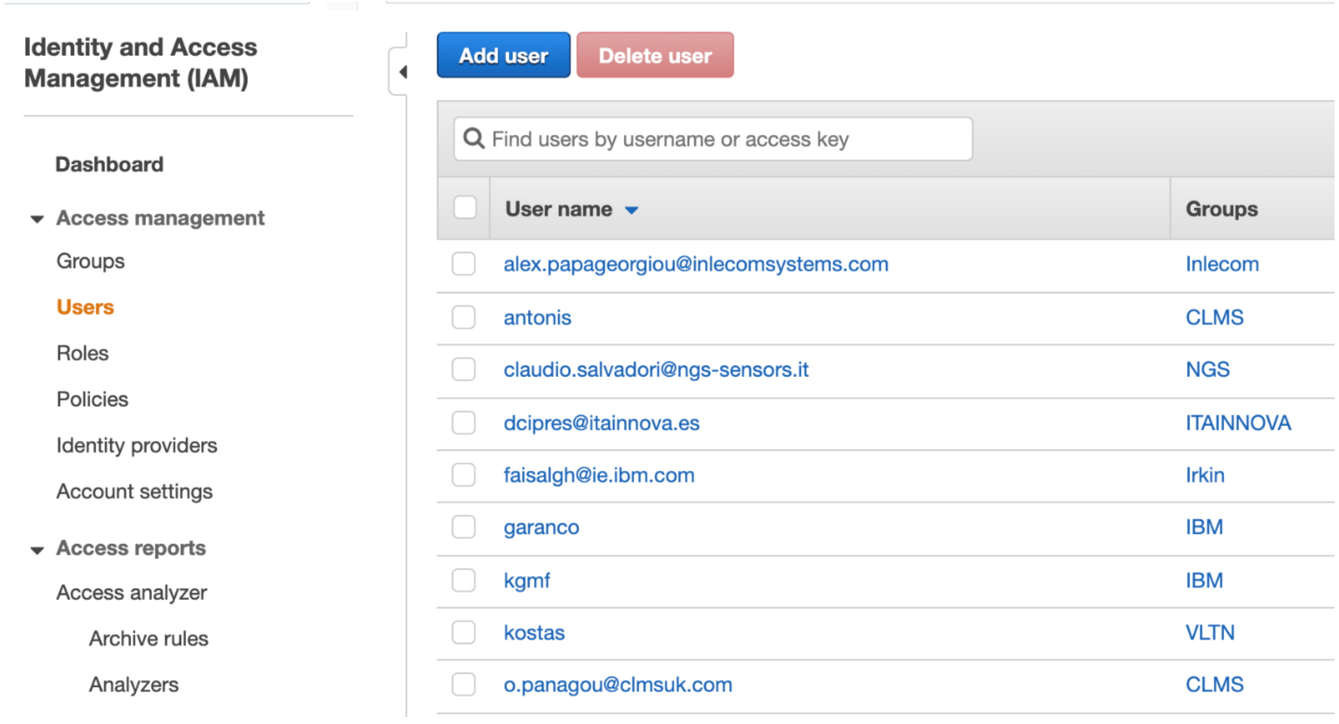
Repositories (12)

View push commands | Delete | Edit | Create repository

Find repositories

Repository name	URI	Created at	Tag immutability	Scan on push	Encryption type
iconet-blockchain	331447178759.dkr.ecr.eu-west-1.amazonaws.com/iconet-blockchain	06/24/20, 12:06:25 PM	Disabled	Disabled	AES-256
iconet-clms-encapsulation	331447178759.dkr.ecr.eu-west-1.amazonaws.com/iconet-clms-encapsulation	04/29/20, 08:17:33 PM	Disabled	Disabled	AES-256
iconet-clms-shipping	331447178759.dkr.ecr.eu-west-1.amazonaws.com/iconet-clms-shipping	04/08/20, 02:20:11 PM	Disabled	Disabled	AES-256
iconet-networking-svc	331447178759.dkr.ecr.eu-west-1.amazonaws.com/iconet-networking-svc	04/02/20, 02:08:15 PM	Disabled	Disabled	AES-256
iconet-opt	331447178759.dkr.ecr.eu-west-1.amazonaws.com/iconet-opt	02/03/20, 11:31:48 AM	Disabled	Disabled	AES-256
iconet-router	331447178759.dkr.ecr.eu-west-1.amazonaws.com/iconet-router	04/02/20, 10:27:06 AM	Disabled	Disabled	AES-256
iconet-router-ll3	331447178759.dkr.ecr.eu-west-1.amazonaws.com/iconet-router-ll3	09/18/20, 03:22:55 PM	Disabled	Disabled	AES-256
iconet/ngs/api-manager/shipment-service-api	331447178759.dkr.ecr.eu-west-1.amazonaws.com/iconet/ngs/api-manager/shipment-service-api	04/28/20, 07:57:03 PM	Disabled	Enabled	AES-256
iconet/ngs/iot-manager/iot-parser-api	331447178759.dkr.ecr.eu-west-1.amazonaws.com/iconet/ngs/iot-manager/iot-parser-api	04/29/20, 06:21:45 PM	Disabled	Enabled	AES-256
iconet/ngs/python-poetry	331447178759.dkr.ecr.eu-west-1.amazonaws.com/iconet/ngs/python-poetry	04/23/20, 09:59:39 AM	Disabled	Enabled	AES-256
iconet/ngs/storage-services/iot-service	331447178759.dkr.ecr.eu-west-1.amazonaws.com/iconet/ngs/storage-services/iot-service	04/29/20, 12:20:49 PM	Disabled	Enabled	AES-256
iconet/ngs/storage-services/shipment-service	331447178759.dkr.ecr.eu-west-1.amazonaws.com/iconet/ngs/storage-services/shipment-service	04/28/20, 02:26:12 PM	Disabled	Enabled	AES-256



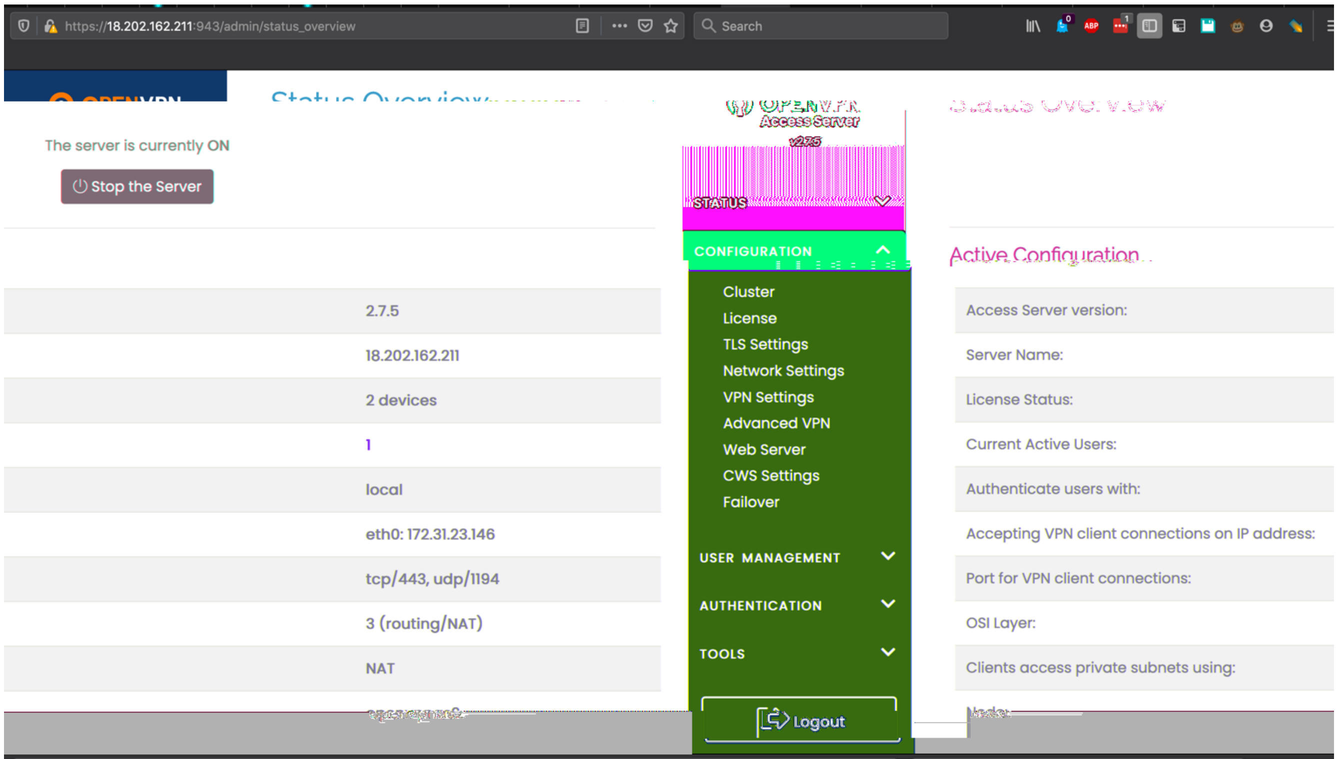

Identity and Access Management (IAM)

- Dashboard
- Access management
  - Groups
  - Users
  - Roles
  - Policies
  - Identity providers
  - Account settings
- Access reports
  - Access analyzer
    - Archive rules
    - Analyzers

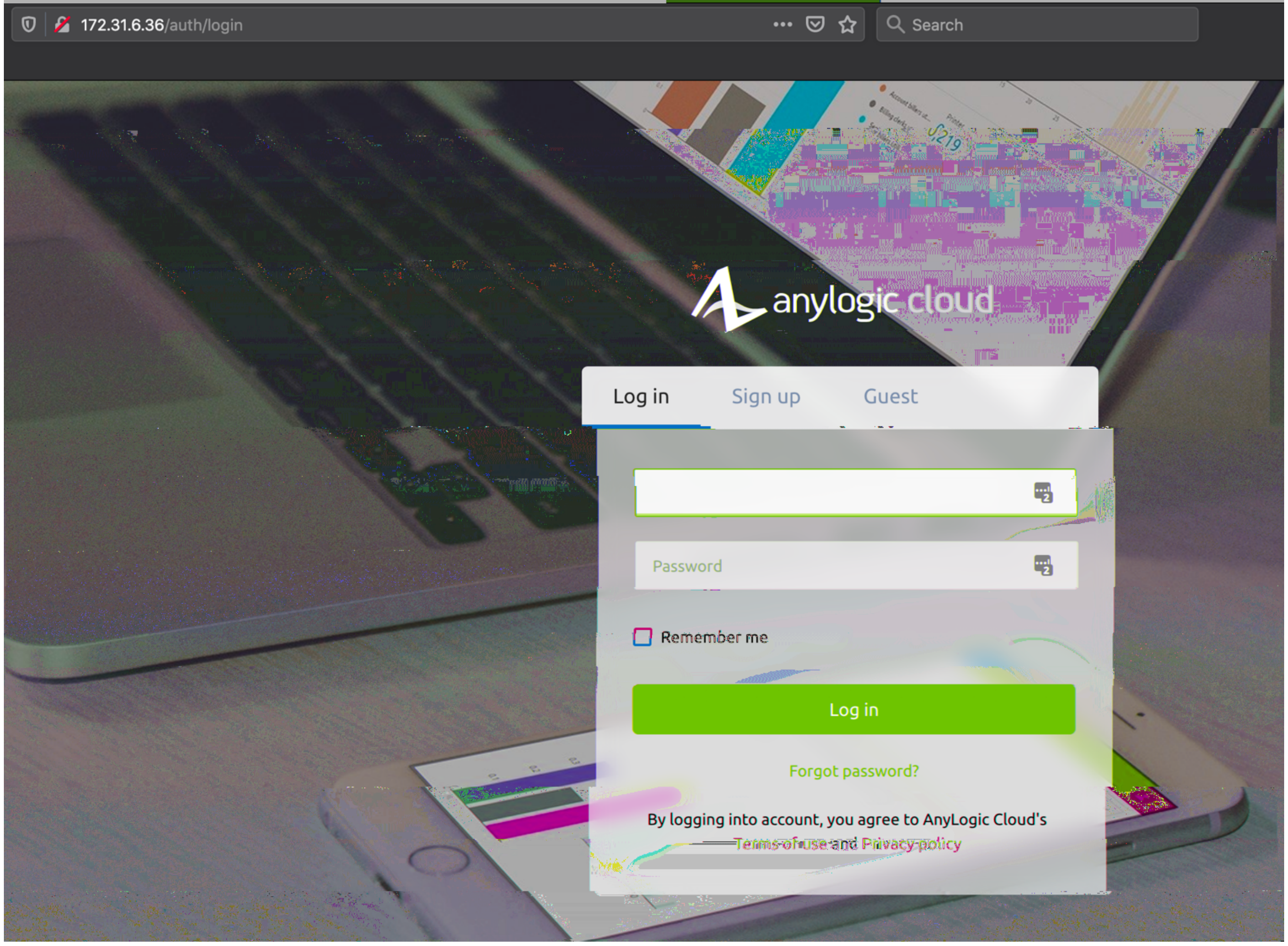
Add user | Delete user

Find users by username or access key

User name	Groups
alex.papageorgiou@inlecomsystems.com	Inlecom
antonis	CLMS
claudio.salvadori@ngs-sensors.it	NGS
dcipres@itainnova.es	ITAINNOVA
faisalgh@ie.ibm.com	Irkin
garanco	IBM
kgmf	IBM
kostas	VLTN
o.panagou@clmsuk.com	CLMS



Access Server version:	2.7.5
Server Name:	18.202.162.211
License Status:	2 devices
Current Active Users:	1
Authenticate users with:	local
Accepting VPN client connections on IP address:	eth0: 172.31.23.146
Port for VPN client connections:	tcp/443, udp/1194
OSI Layer:	3 (routing/NAT)
Clients access private subnets using:	NAT



Bibliography

[1] “nxtPort - About,” [Online]. Available: https://www.nxtport.com/about.

[2] “What is Amazon VPC,” [Online]. Available: https://docs.aws.amazon.com/vpc/latest/userguide/what-is-amazon-vpc.html.

[3] “Internetwork Traffic Privacy in Amazon VPC,” [Online]. Available: https://docs.aws.amazon.com/vpc/latest/userguide/VPC_Security.html.

[4] “What is Amazon EC2?,” [Online]. Available: https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/concepts.html.