Modularity – Proposal for achieving functional decomposition

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(with input from Alex Vul, Parviz Yegani, Nigel Davis)

Modularity

How functional capabilities can be decomposed and regrouped for flexible deployments, to create functional variations.

How to decompose ?

- Based on business/domain capabilities (Domain Driven Design)
- Based on Verb – Example Collect, Analyze, Configure, Decompose ⟵ Followed in ONAP
- Based on Noun/Entities – Example Service, VNF, Policy
- Based on software layers – Example DB layer, UI, Backend ⟵ Followed in ONAP

Why we need modularity ?

- Standardize capabilities
- Have optional alternatives
- Enable functional variations
- Enable flexible deployment patterns
- Enable model driven capabilities

Microservice Architecture is a natural enabler for modularity

- Independent development and testing
- Enable CI/CD/CT

Modularity, Model Driven, Cloud Native – Some misconception

- Modularity != Microservice
  - Boundary, Style of Decomposition matters
- Model Driven – Model driven for intent or Model Driven for Solution behavior ?
  - Intent: End state to be achieved, represented through IM/DM.
  - Behavior: Behavior of solution to be tuned to achieve an end state represented through configuration model
    - Configuration of modules – Implementation meta model
    - Sequence of actions – Workflow
- Cloud Native != Docker , != K8S , != Cloud based
  - Applications with built-in capability to leverage the agility and distributed nature of Cloud environment

Problem Statement 1: Modularity – Terminology and Functional Composition

How Modularity achieved today in ONAP ? What is Microservice in ONAP ?

Different views on Microservice

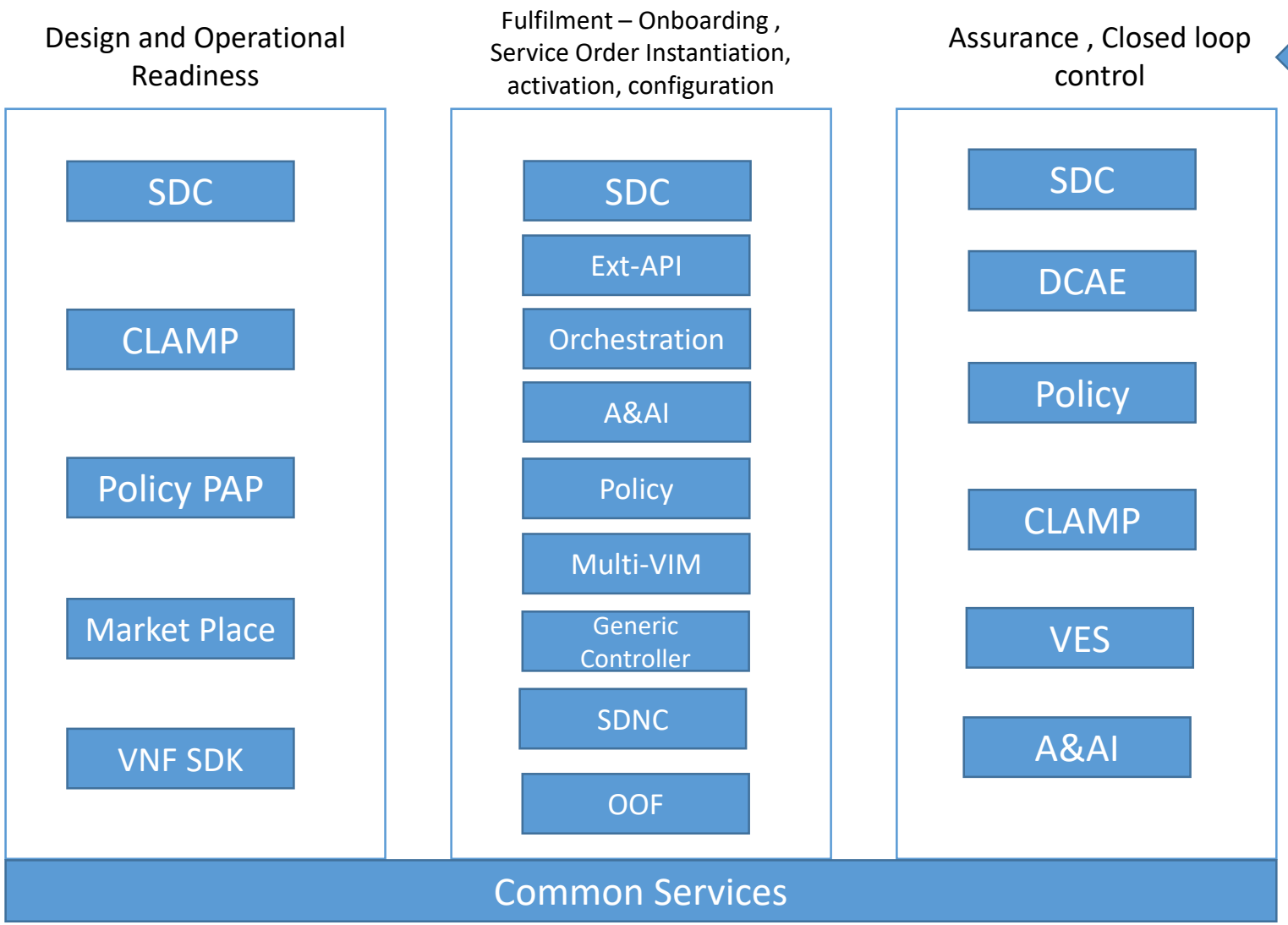
- Docker Container
- POD
- Kubernetes Service
- Kubernetes Deployment
- Component
- A Functional Entity
- API End Point
- Application
- A Feature of an application

- ONAP Follows a Project Specific view of Modularity
- Each project follows own methodology for decomposition of functionality
- Most of the projects follow a software centric functional decomposition rather than domain capability decomposition

- These are all different levels of functionality or characteristic ONAP stake holders use at different context.
- Two aspects to be considered – what is the level of granularity of the functionality , what is the context (deployment, information, run time etc)

ONAP modularity is currently driven by projects with software module (DB, Tools etc) based boundary, not domain capability based boundaries

Problem Statement 2: Modularity and Tight Dependency

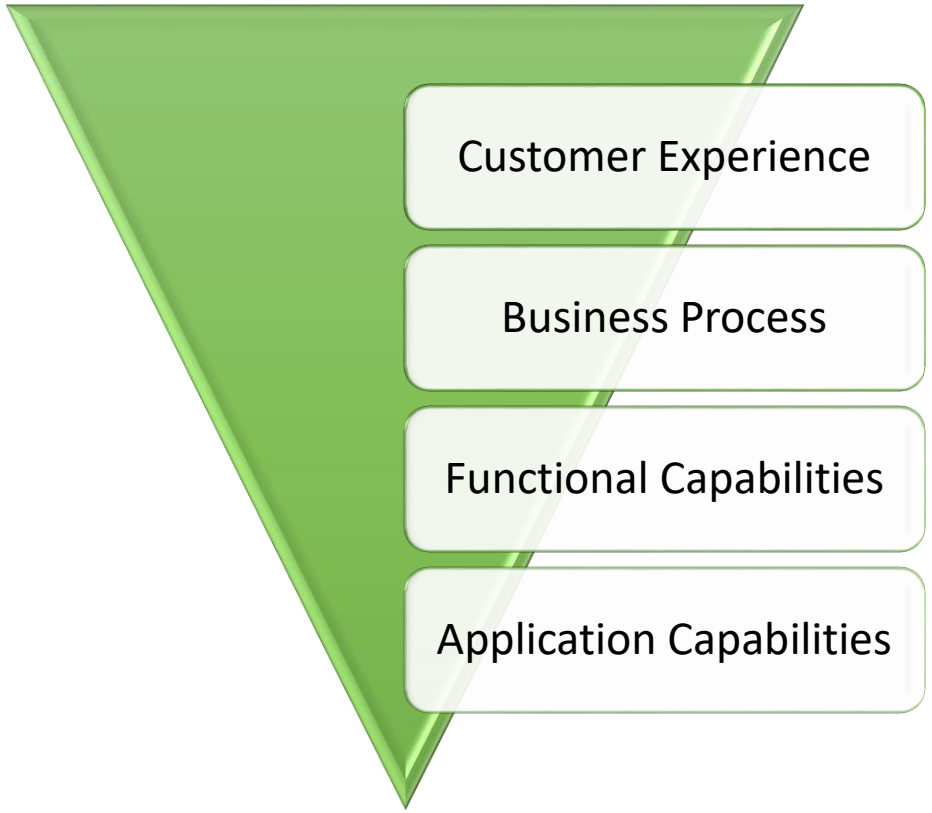


Different functional stacks in ONAP

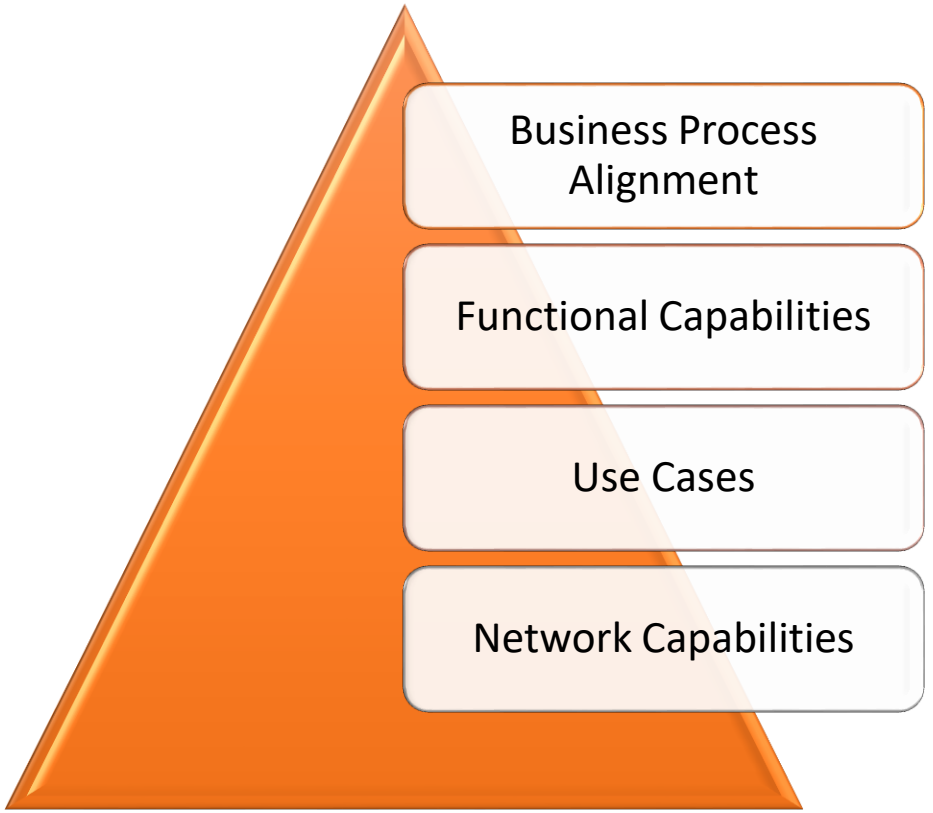
- Heavy fulfilment and assurance stack with tight dependency between components
- Heavy dependency on the design time environment for enabling capabilities
- Each module follows own style and category of APIs and defines own set of entities requiring dependent modules to evolve continuously
- Business logic and internal APIs to access the business logic tightly coupled.
- Operational stacks are not easily replaceable.
- Stack components cannot be easily replaced due to tight dependency

Problem Statement 3: Top-down vs Bottom-up Approach

Typical Service Provider Transformation (Top-down)



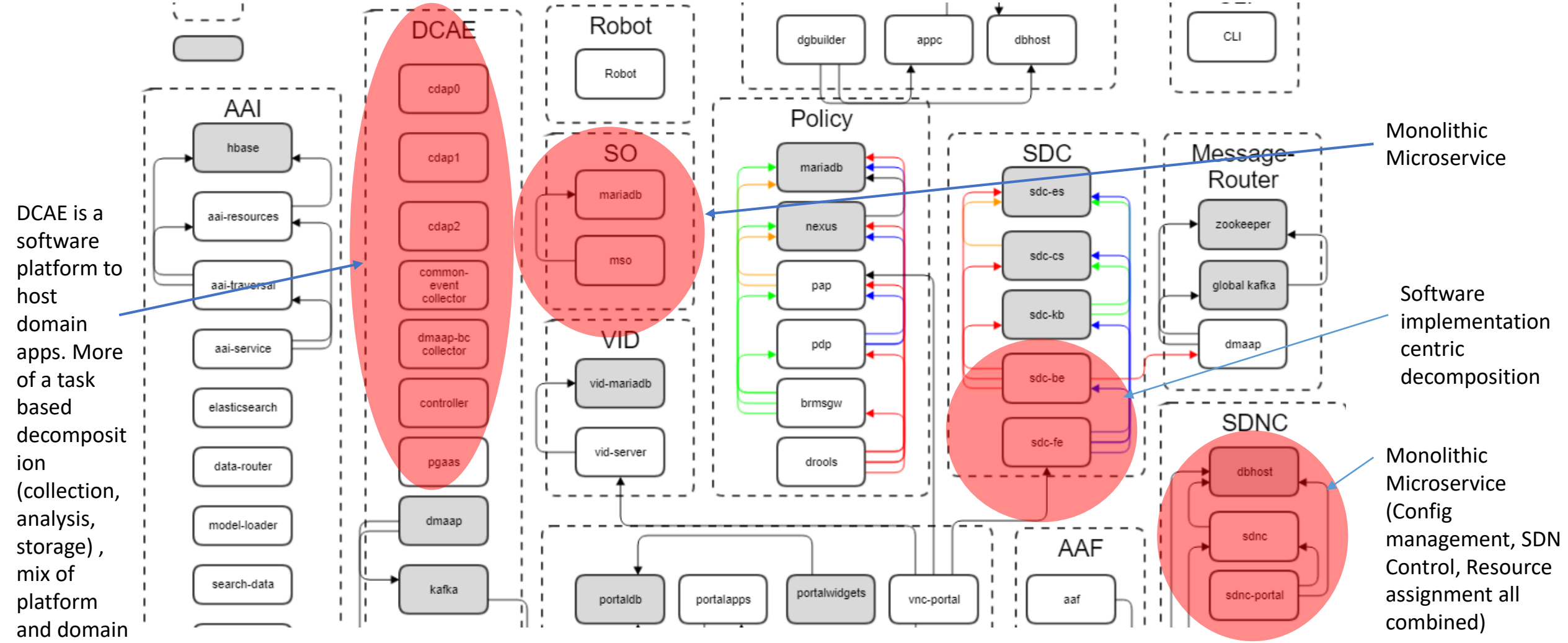
ONAP Approach (Bottom-Up)



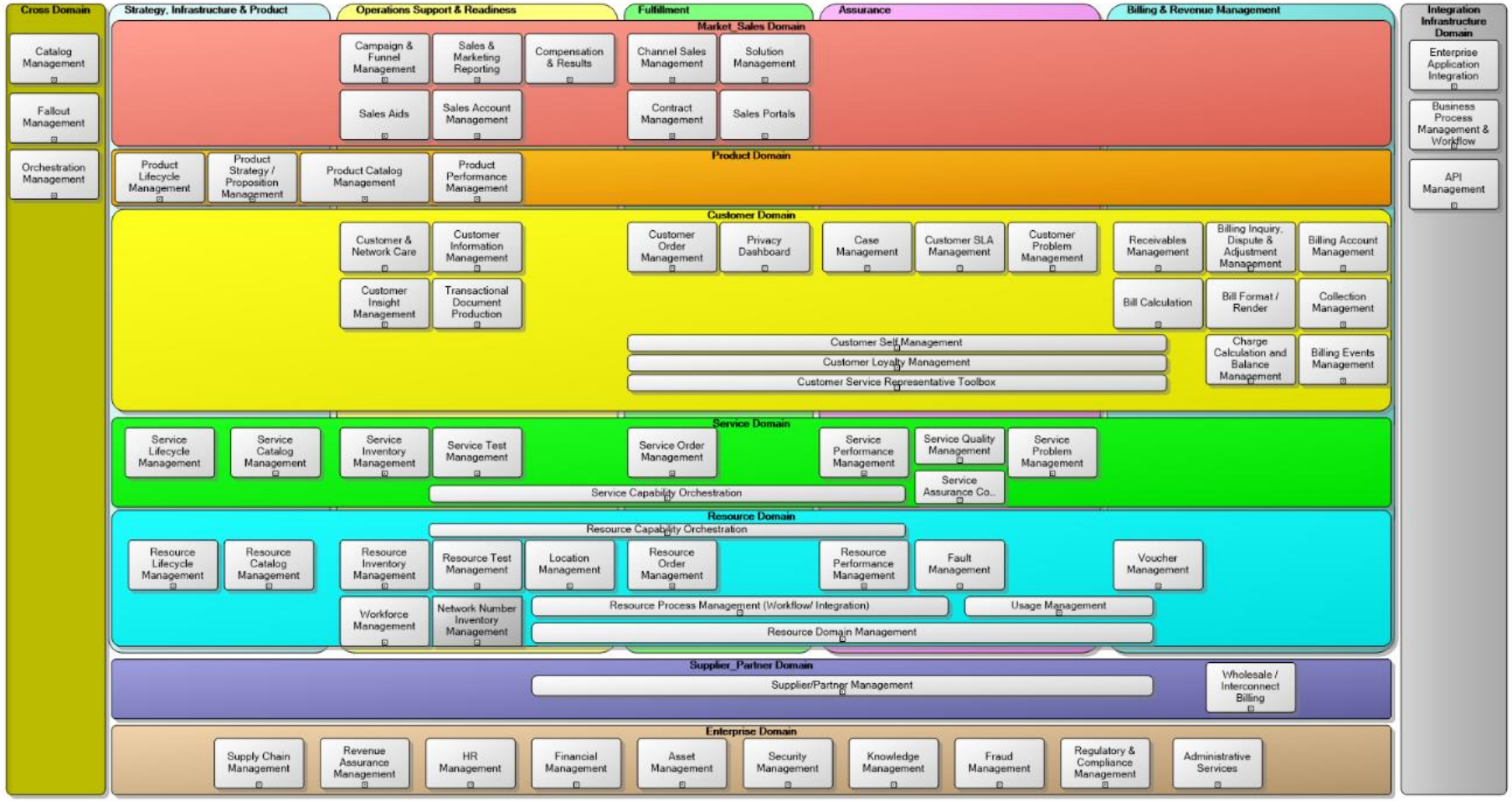
Balancing these two approaches is necessary for production deployment of ONAP
How modular functional capabilities that are aligned to standard business processes help in top-down operational transformation

How ONAP modules are decomposed today ? (Reference Amsterdam Microservices)

Not functional decomposition, but software decomposition, decomposition logic based on discretion of project owner



Modularity : How Microservice Composition can be Represented? Learnings from TMForum TAM



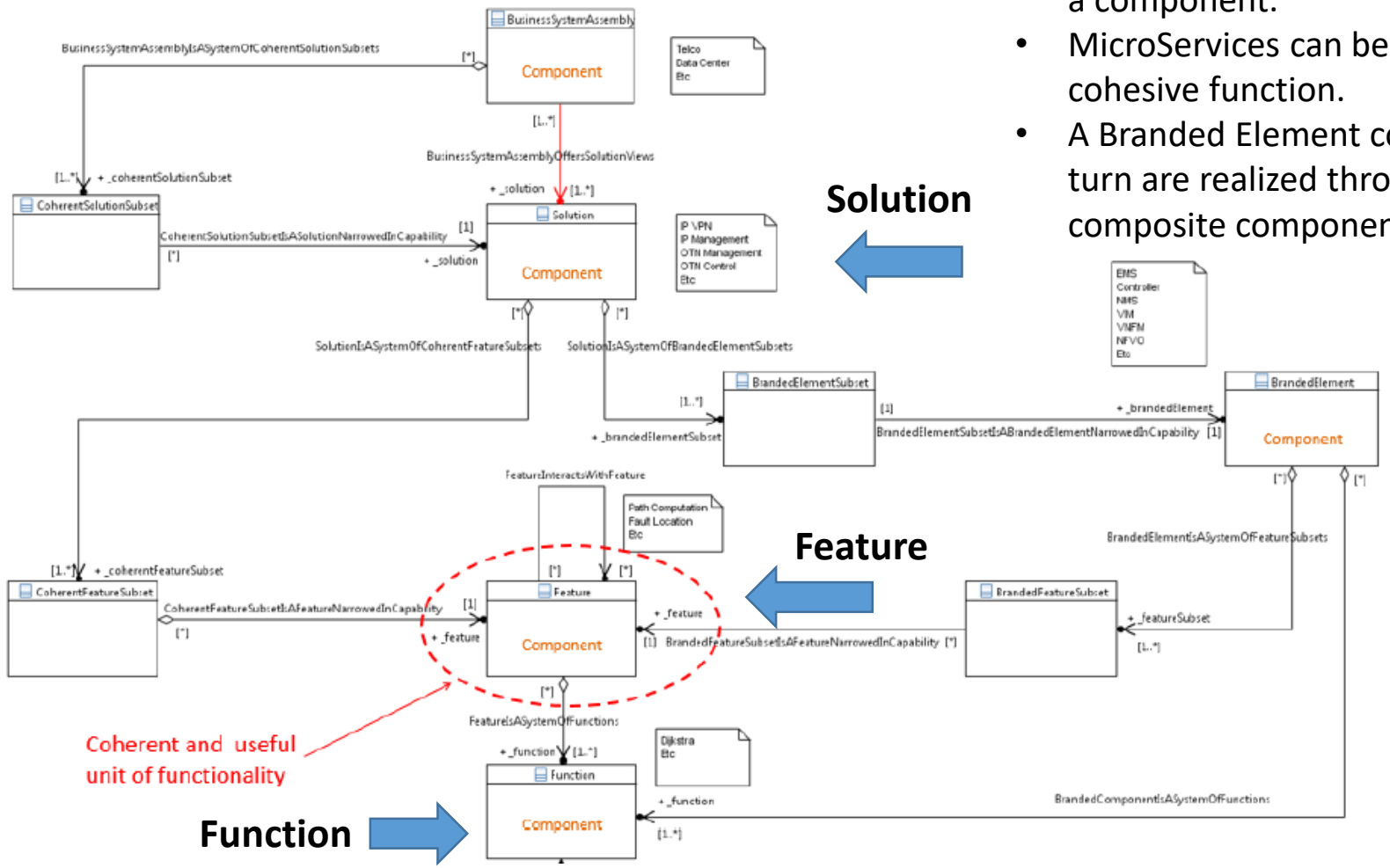
What we can learn from TAM :

- Define Microservice Levels (Level 1, Level 2 etc) that compose domain functions
- Similar (need not be same) in concept to TMForum TAM with different levels of application capability decomposition.
- Gives option to select the application capabilities based on the well known TAM like capability decomposition map.
- End user can select the capability and associated micro services (at any level) enabling those capabilities.
- Help identify functions and associated stake holders in ONAP at different levels of granularity

Benefits

- **Consistency in Functional decomposition**
- **Single terminology across layers and across projects**
- **Close relationship with Business process terminology and business process flows**
- **Can reference APIs (Open APIs) rather than proprietary APIs**

TMF IG1118: Positioning of a Component in a hierarchy of modular constructs

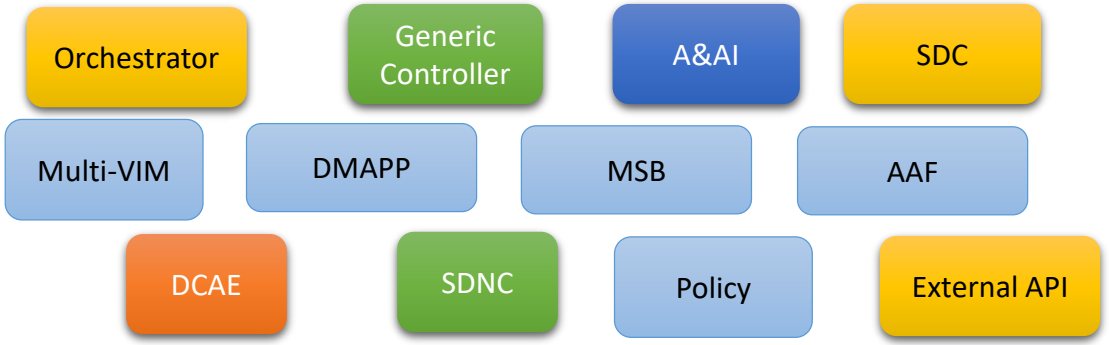


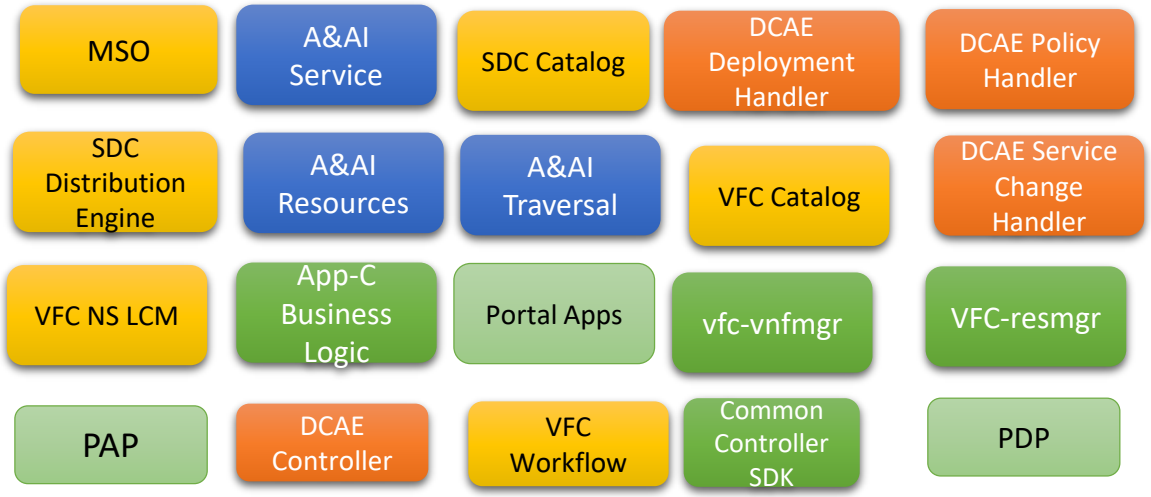
- A component-system pattern is fractal, split a component and you get more components, combine components and you get a component.
- MicroServices can be perceived as a component fulfilling a cohesive function.
- A Branded Element constitutes of multiple features which in turn are realized through set of functions – all levels can be a composite component.

All different levels of microservice – Macroservice, Miniservice, Microservice

ONAP Capability Decomposition vs TAM Levels (Example – Not Complete)

ONAP Components





ONAP Microservices with core domain logic

TAM Level 1

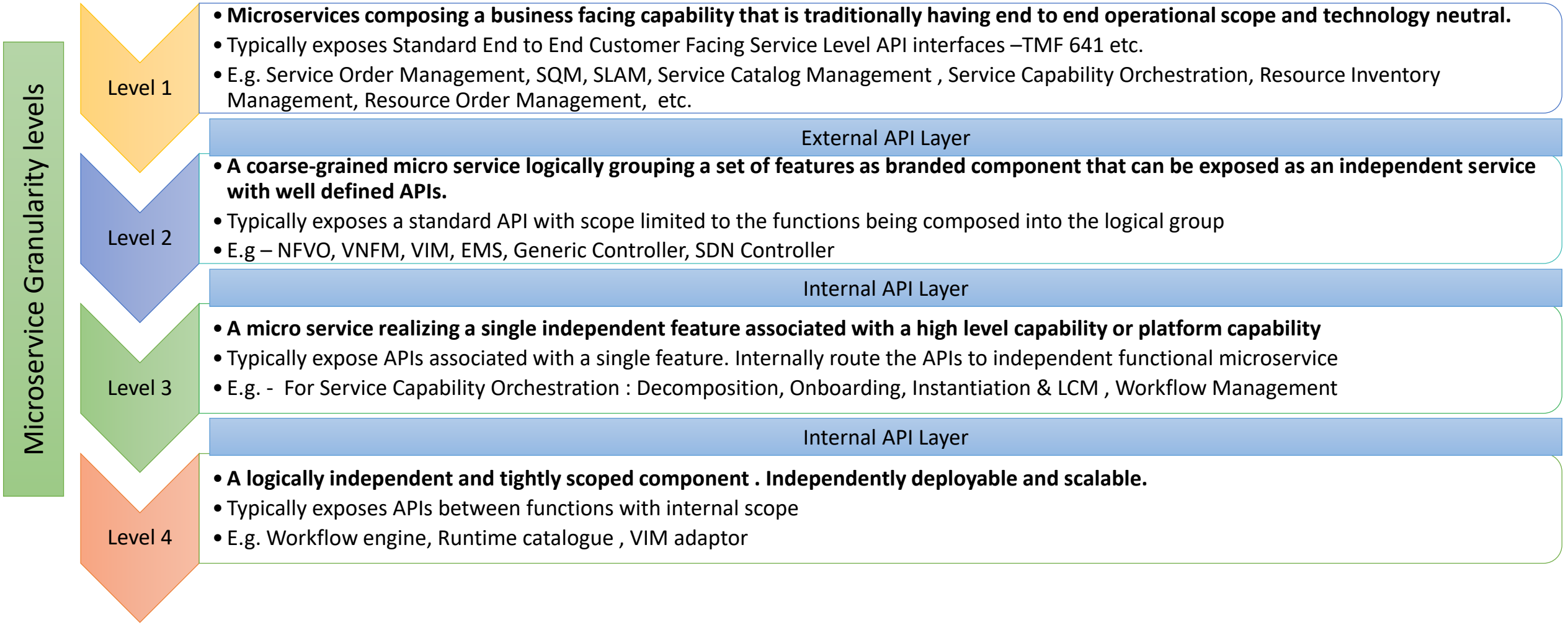
Service Capability Orchestration	Service Inventory Management	Service Performance Management
Service Order Management	Service Quality Management	Service Assurance Control
Resource Catalog Management	Resource Inventory Management	Resource Performance Management
Resource Capability Orchestration	Resource Fault Management	Resource Lifecycle Management

TAM Level 2

Service Activation Management	Service Inventory Reconciliation	Service-Resource Inventory
Service Design and Assign	Service Configuration Management	Service Order Orchestration
Service Workflow Control	Service Performance Monitoring	Service Instantiation and LCM
Service Quality Collection & Monitoring	Service Quality Reporting	Resource Inventory Reconciliation
Service Quality Analysis	Service Onboarding	Service Quality Model Establishment
Service Workflow Configuration	Service Decomposition	Service Performance Reporting
Resource Commissioning & CM	Service Performance Analysis	Resource Inventory Update
Resource Inventory Retrieval	Resource Design and Assign	Resource Order Orchestration
Resource Discovery	Resource Activation	Resource Fault & Performance Data Mediation

Modularity through Microservices

A functional capability expressed in multiple levels of granularity. Each granular level is independently deployable, expose well defined APIs. Granularity level left to the user - what independent capability mix is required at what level .



Level 0 is assumed to be a Solution which is composed of Level 1 MS – E.g. Domain Orchestrator

Modularity through Microservices: Personas at each level

Level 0 is assumed to be a Solution which is composed of Level 1 MS – E.g. Domain Orchestrator

Modularity – Functional Layering (Only for representation, not complete)

Level 1

- Service Order Management
- Service Inventory Management
- Service Lifecycle Management
- Service Capability Orchestration
- Service Test Management
- Service Performance Management
- Service Problem Management
- Service Quality Management
- Service Assurance Control
- Resource Catalog Management
- Resource Lifecycle Management
- Resource Test Management
- Resource Order Management
- Resource Performance Management
- Resource Capability Orchestration
- Resource Fault Management
- Resource Domain Management
- Resource Usage Management

Level 2

- Orchestrator
- VNF Manager
- VIM
- SDN Controller
- EMS
- SDC
- NMS
- DCAE
- Multi-VIM
- Policy
- A&AI
- Ext-API

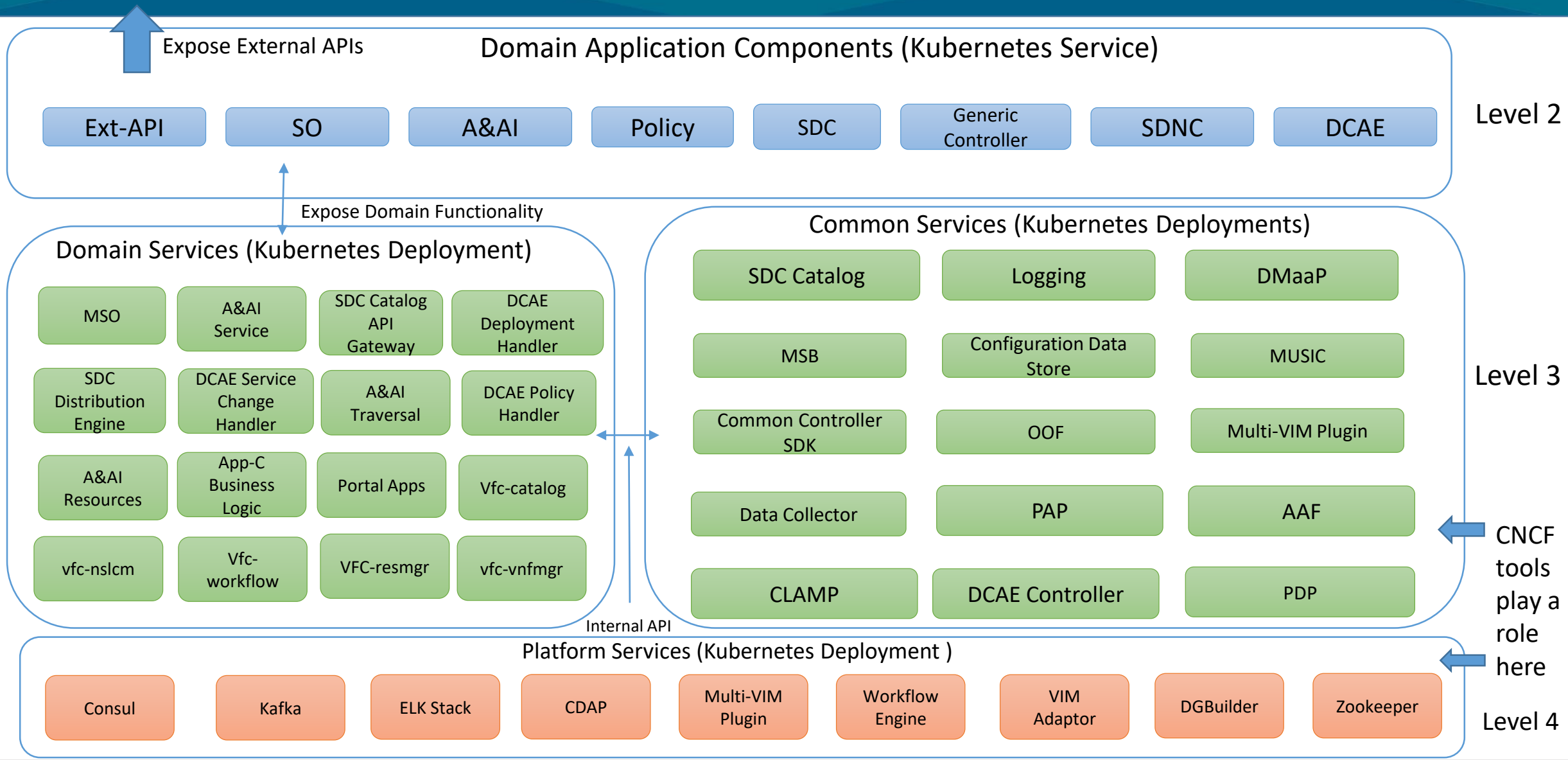
Level 3

- Service Design and Assign
- Service Order Orchestration
- Service Configuration Management
- Service Activation Management
- Service Inventory Reconciliation
- Service-Resource Inventory
- Service Instantiation and LCM
- Service Decomposition
- Service Onboarding
- Service Workflow Configuration
- Service Workflow Control
- Service Performance Monitoring
- Resource Commissioning & CM
- Service Performance Analysis
- Service Performance Reporting
- Service Quality Model Establishment
- Service Quality Collection & Monitoring
- Service Quality Analysis
- Service Quality Reporting
- Resource Inventory Reconciliation

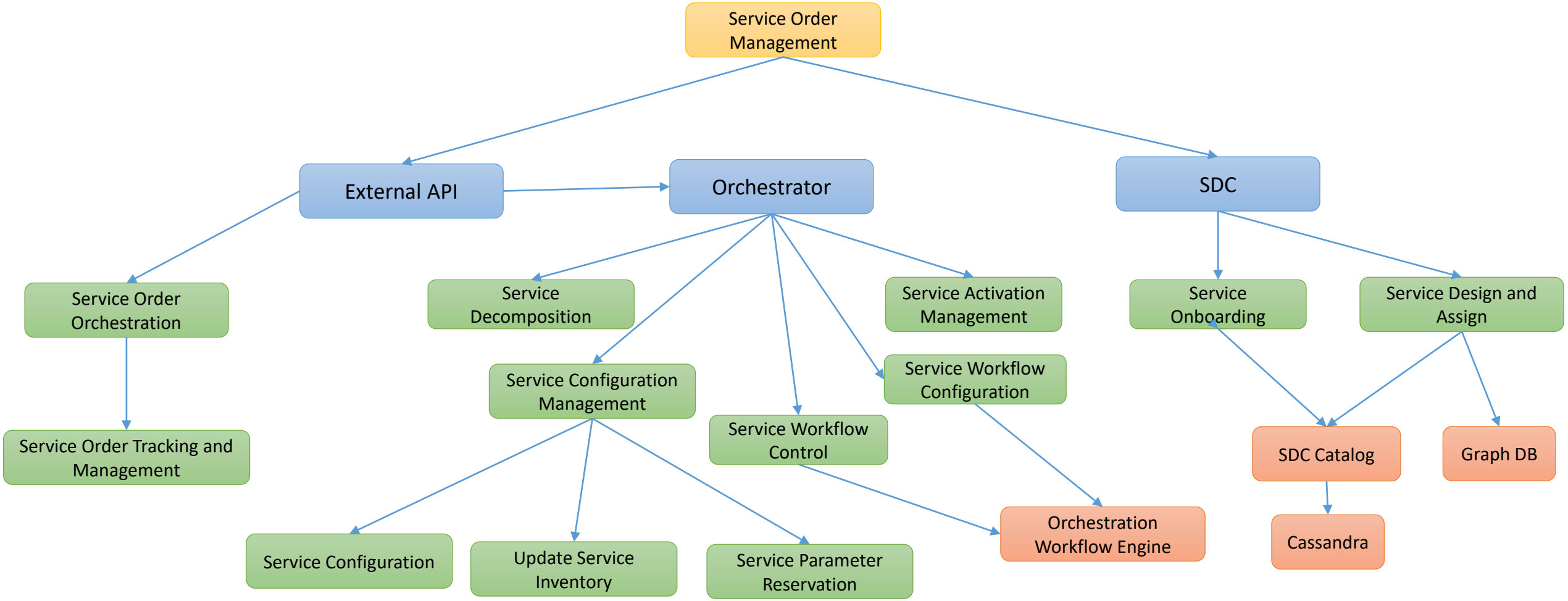
Level 4

- DMaaP Message Router
- DMaaP Data Router
- MSB Registration Proxy
- MSB Service Discovery Cluster
- SDC Persistent Store
- Orchestration Workflow Engine
- Consul Cluster
- Common Controller SDK
- Kubernetes
- Distributed Data Store
- Multi-VIM Plugin
- VIM Adaptor

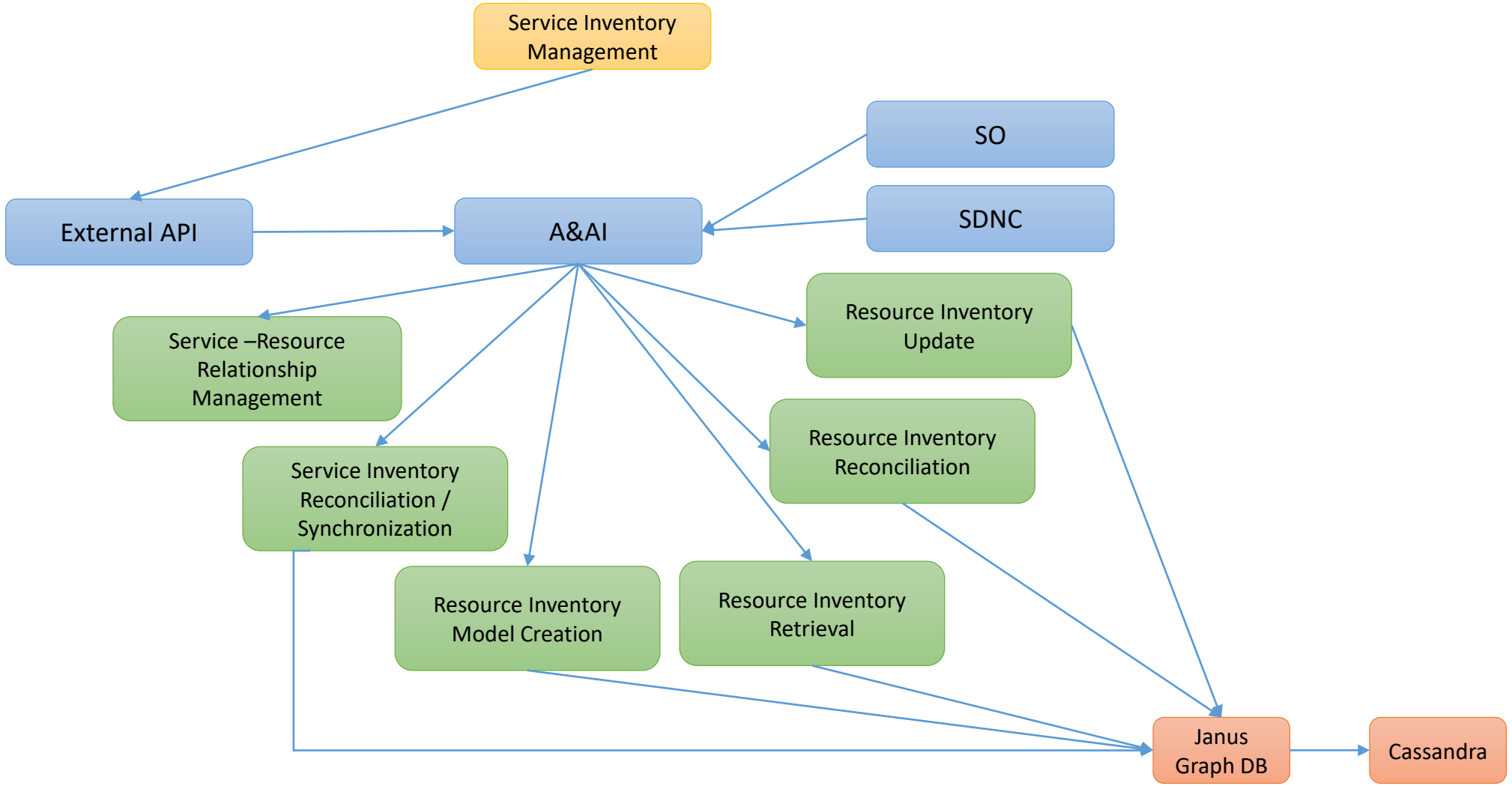
Alternate Layering/Grouping of Microservices for Modularity



ONAP Capabilities mapped to TAM (Example 1)



ONAP Capabilities mapped to TAM (Example 2)



Mapping of Microservice Levels to ONAP (Example - Not Complete – As-Is)

Level 1

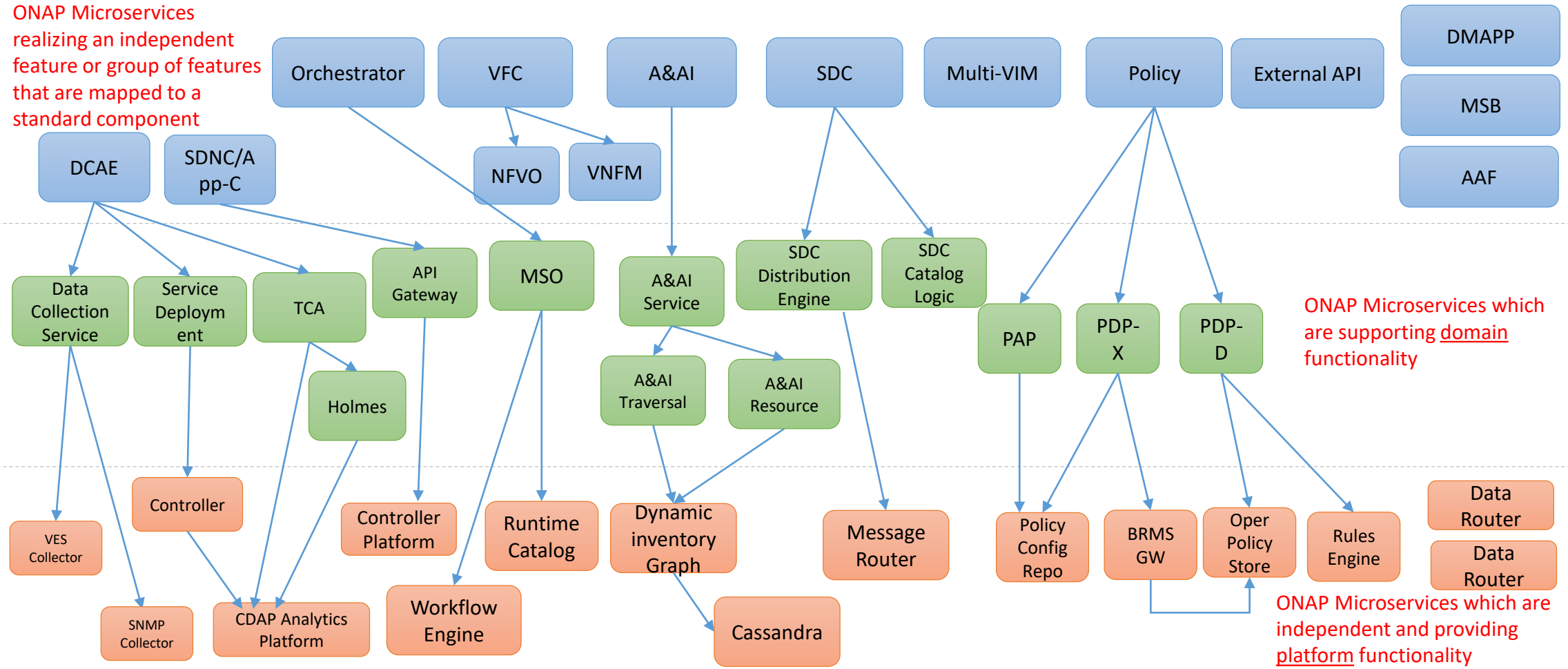
Identify functional levels of existing microservice

Level 2

ONAP Microservices realizing an independent feature or group of features that are mapped to a standard component

Level 3

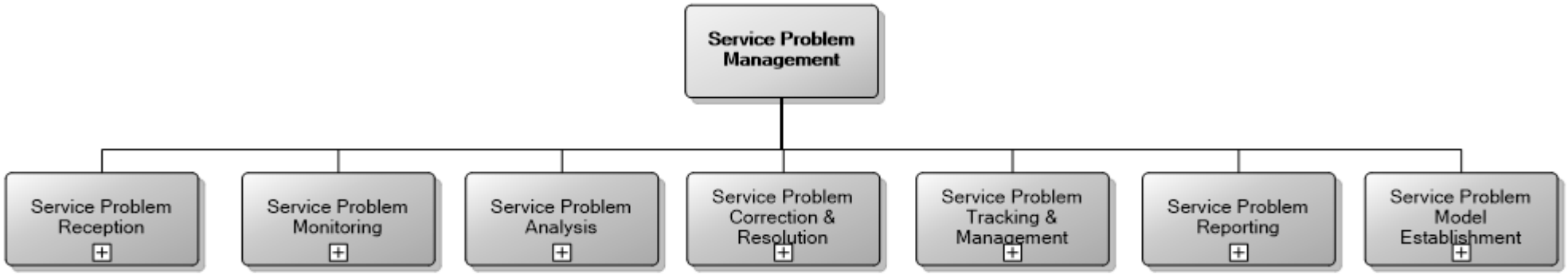
Level 4

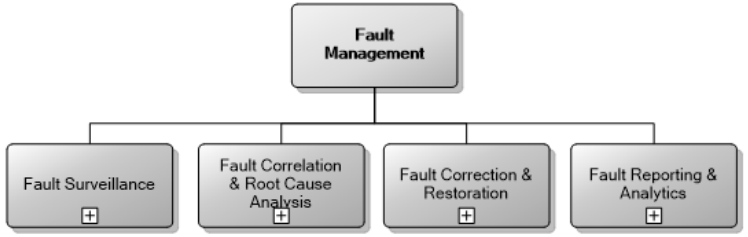


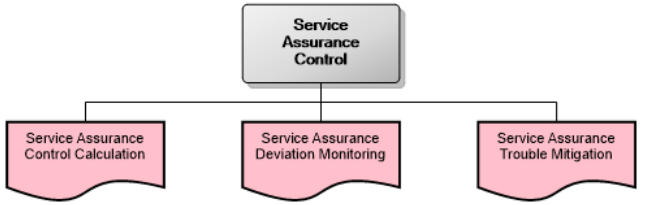
Tiger team feedback (Alex, Parviz, David, Nigel)

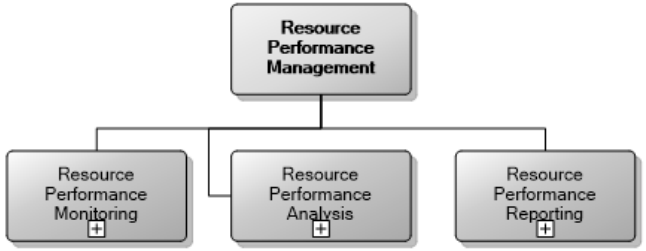
- API Alignment – External and Internal API
  - This may be the first step in decomposing domain functionality without making any major structural change of projects
- Service Mesh and CNCF Project (Parviz's Slide deck) Integration
  - Increased interest in CNCF toolset, how a Service mesh based "intelligent edge- dump pipe" model can be achieved
- Statelessness of Microservice
- Transaction support across microservices (Do we really need this?)
- What changes required in CI/CD/CT to support Modularity – Automated Integration Tests , modular deployment composition.

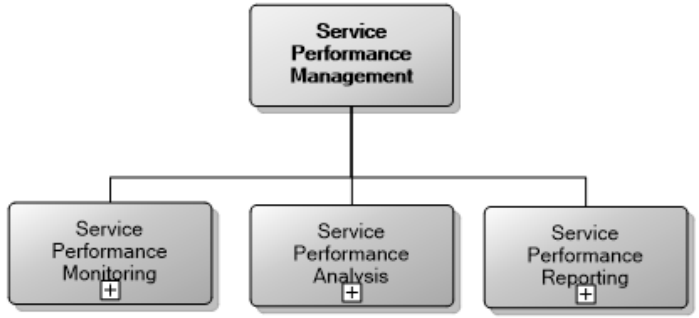
Service/Resource Problem/Performance Management – Typical functional decomposition – Reference TMF TAM



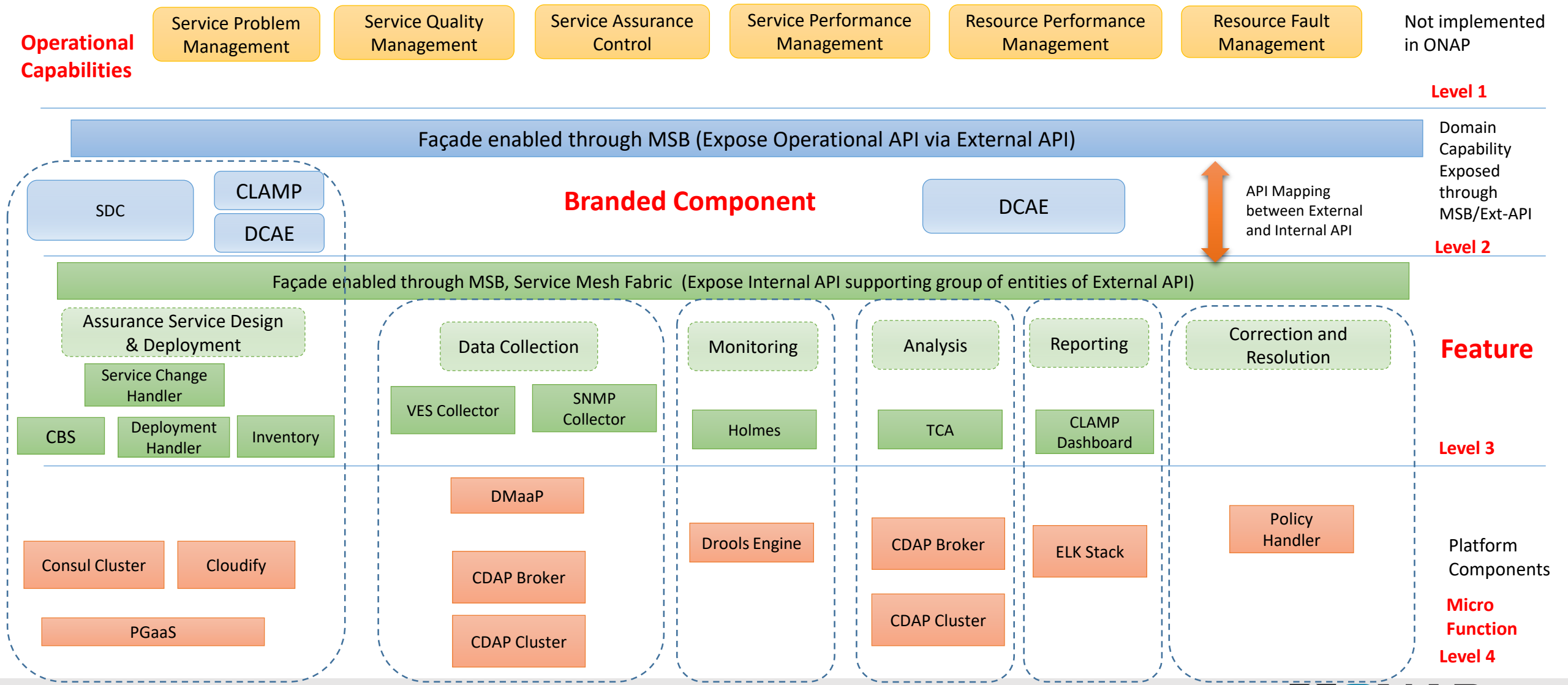








Microservice Functional Decomposition – Example DCAE



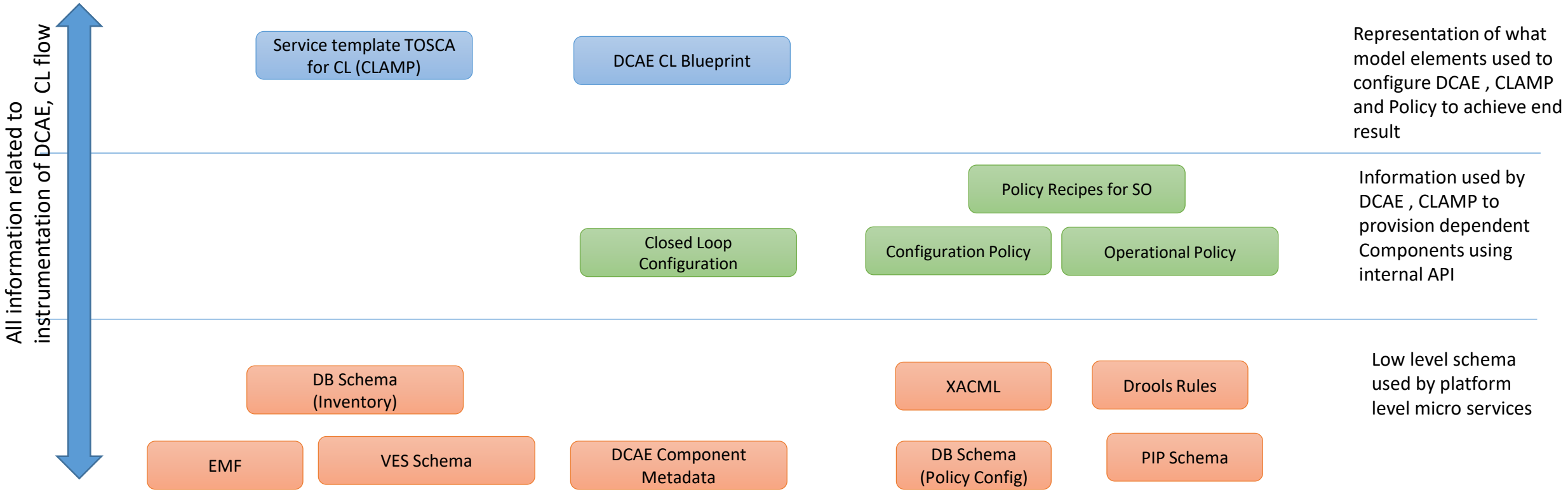
Functional Decomposition – Observation

- Operational capabilities currently supported in ONAP are not easily decomposable – vertically or horizontally - as there is tight coupling between different microservices
- This will limit an operator's preference for top down approach of operational capability enablement
- Need to identify and logically separate (at least at the API level) domain specific capabilities that can be easily identified for defining business process flows

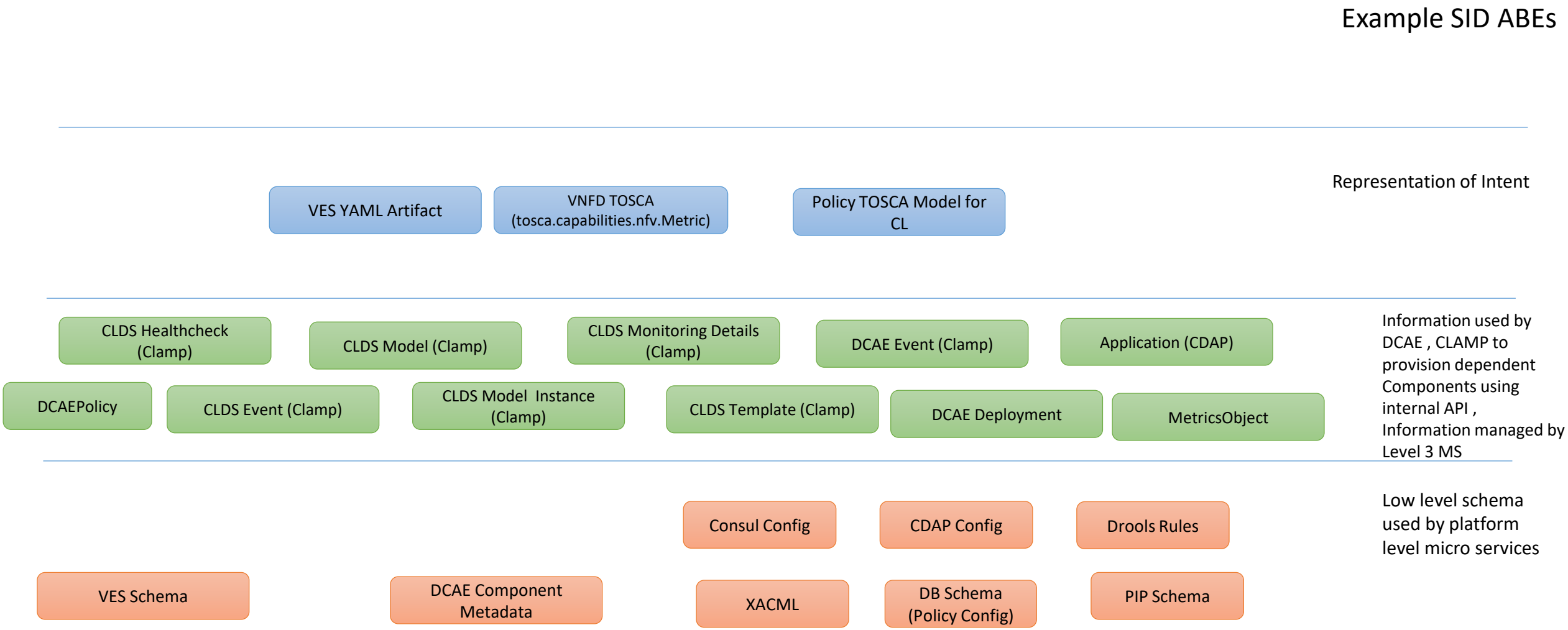
Information Context of Microservices – Key Considerations

- In ONAP there are different types of models used to control different aspect of Microservices
  - behavioral aspect – To represent intended behavior of Microservice which are represented as configurations to achieve model driven capabilities – this may be required to control MS behavior at runtime
  - end result aspect/Intent – To represent end state expected to be achieved as per business and customer demand– This may be an input to microservices to carry out various actions
  - deployment aspect – To represent how microservices are deployed and functionalities are realized – For various deployment options
- All these aspects can be mapped to microservice layers

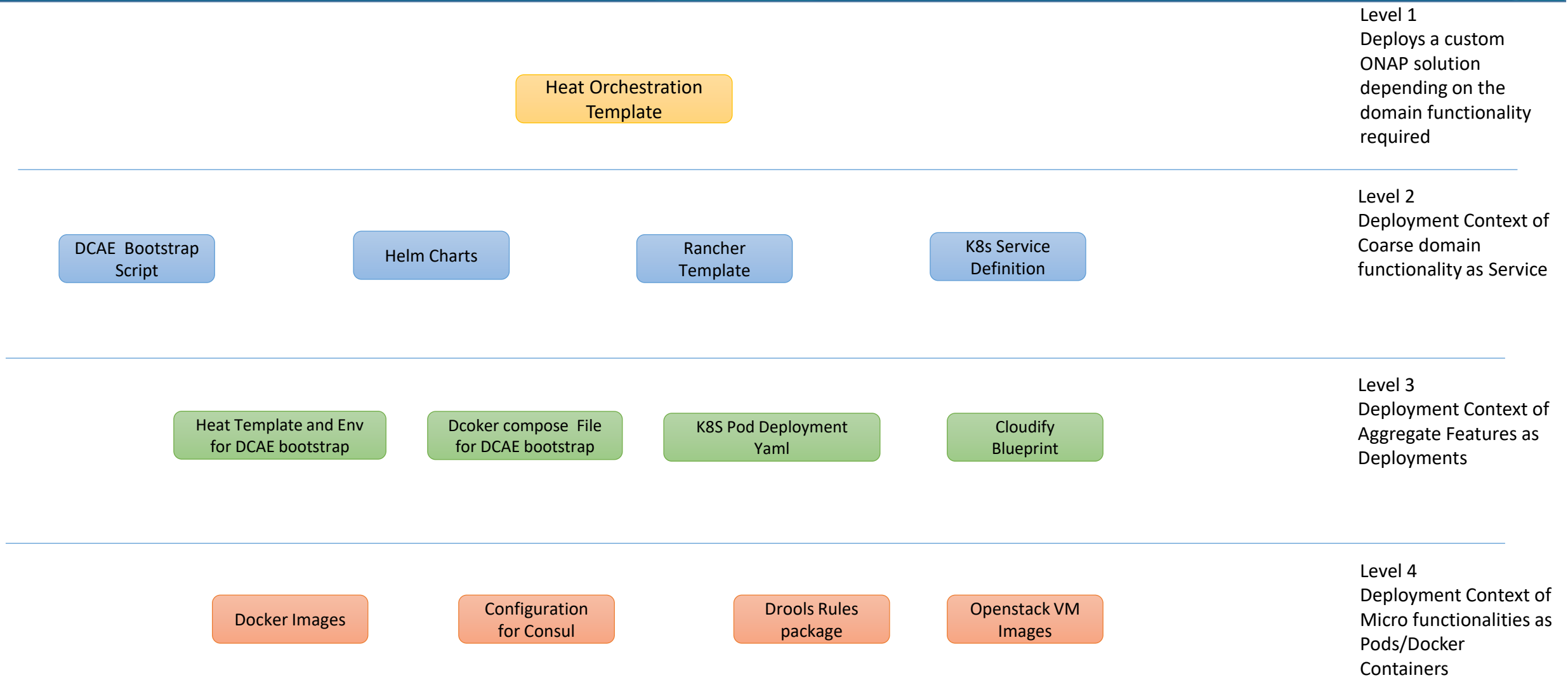
Information Context – Behavioral Aspect - Example DCAE - (To be verified by OOM & DCAE)



Information Context – Intent – Example DCAE - (To be verified by OOM & DCAE)



Deployment Aspect– Deployment Configuration for each Microservice Layers (To be verified by OOM & DCAE) – Example DCAE



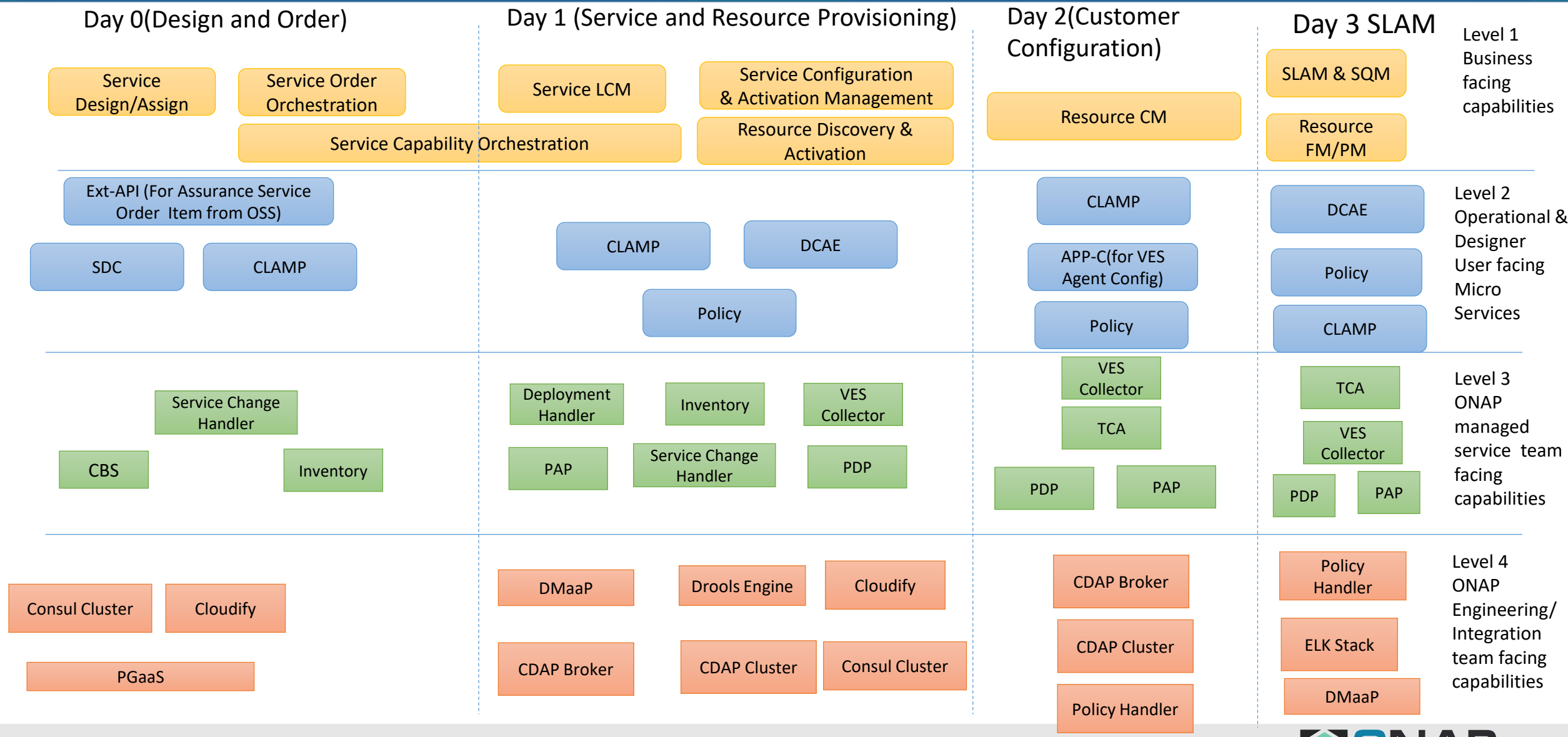
Observation on Information Context

- No clear differentiation between behavioral aspect (configuration of MS), and intent (what to be achieved – create CL).
- Majority of entities managed by Microservices are those to deal with platform capabilities
- Not all domain capabilities are available as managed entities

Operational Context 1/2

- Day 0:
  - Receives service order for enabling end to end service
  - Wait for notification from BSS on availability of partner services/resources
- Day 1 :
  - Query ONAP Service catalog for the infrastructure service corresponding to the partner domain (Not done currently)
  - Send an activation request to partner domain for infrastructure service (Not done currently)
  - Place a service instantiation request on ONAP over ETSI Os-Ma
  - Carry out end to end testing (Not done currently)
- Day 2:
  - Send the customer configuration in terms of FW, QoS, performance monitoring configurations to partner SDNC over TAPI interface
- Day 3:
  - Tune partner SDNC to meet end to end SLA.

Operational Context – 2/2 – DCAE



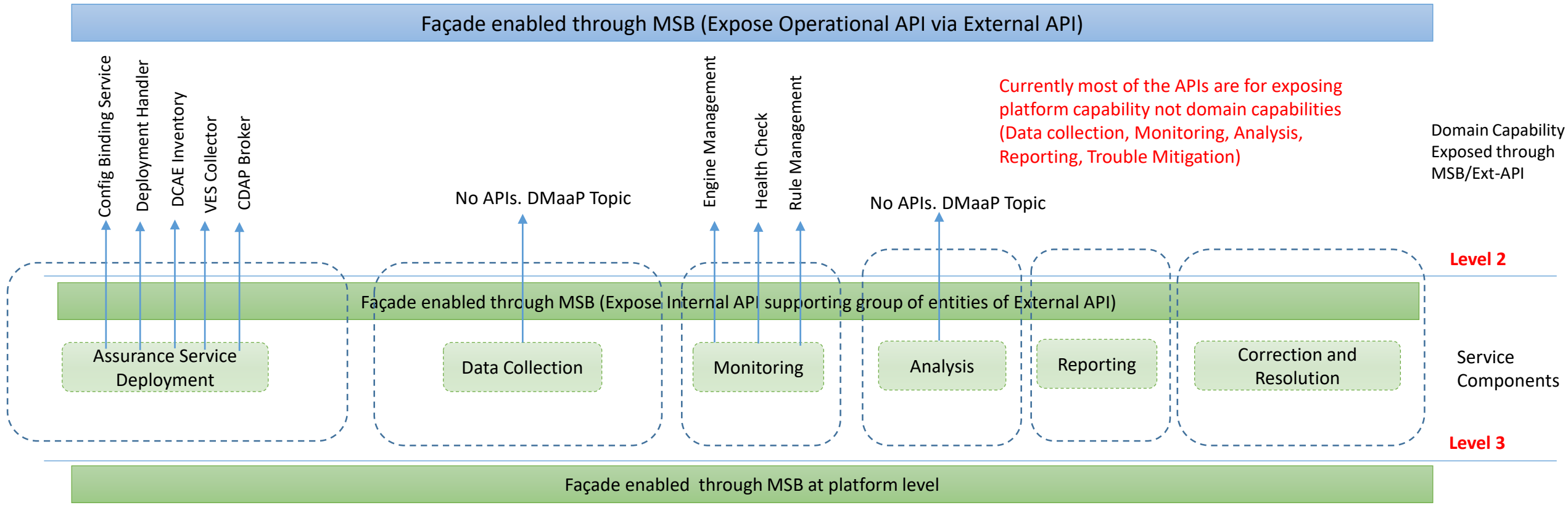
Observation on Operational Context

- Functional overlap between Day 0 to Day 3 Operational Functions
- From Managed Services point of view it will be difficult to segregate the stages of operations as same functions repeat across operational stages.
- Level 4 support teams for Operations (Typically engineering) need to be expertise across different branded components to provide effective support

API Across MS Layers – Example DCAE – AS IS

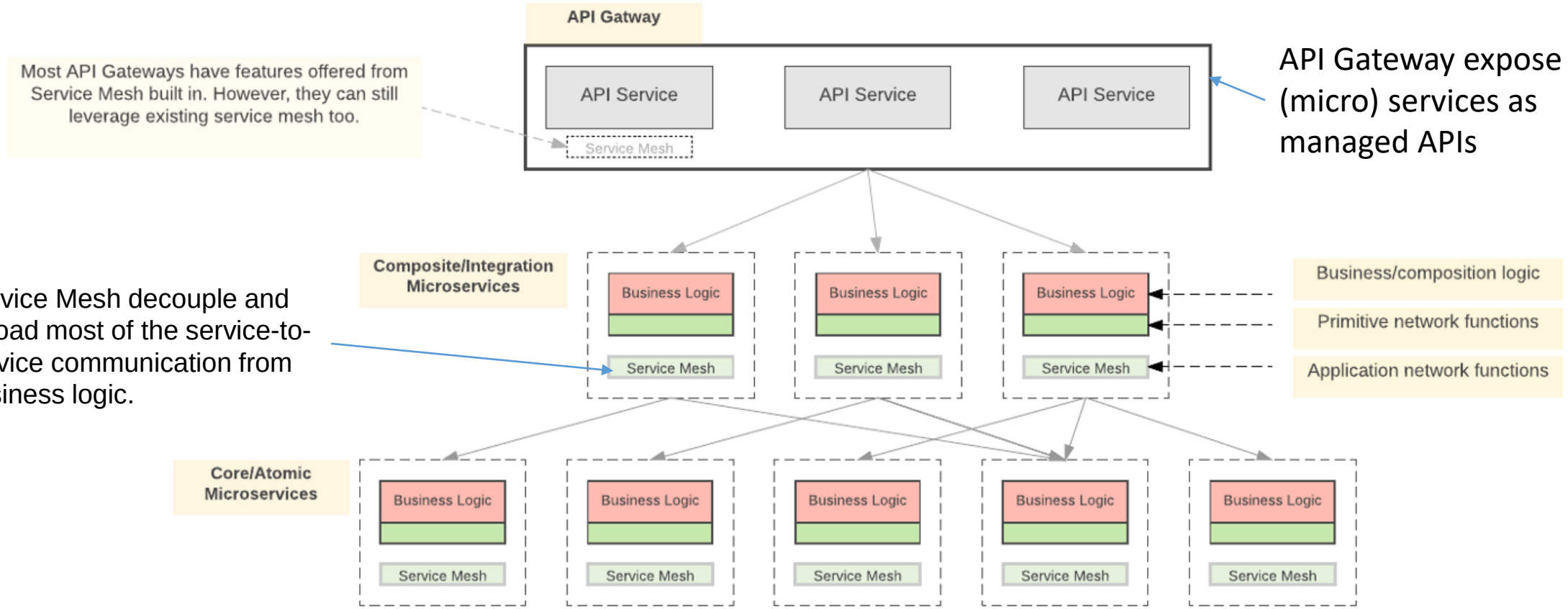
Currently none of the Assurance capabilities are exposed through Ext-API

Not implemented in ONAP



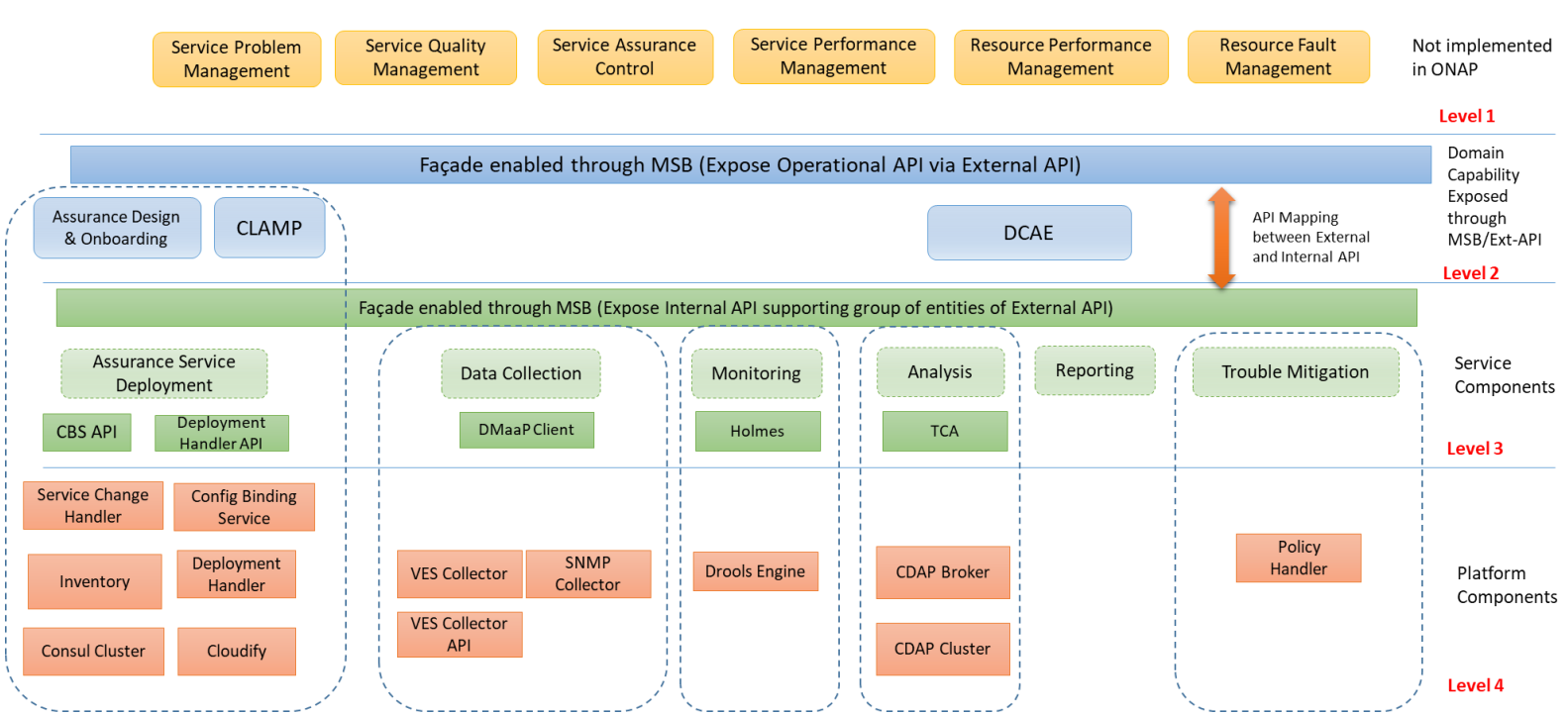
Alex : Façade for micorservices – Focus on the functional APIs and expose those from microservices

API Gateway and Service Mesh



Service mesh is merely an inter-service communication infrastructure which doesn't have any business notion. So it will be ideal to be used at lower levels of Microservices.

API Mapping External vs Internal APIs – Example DCAE

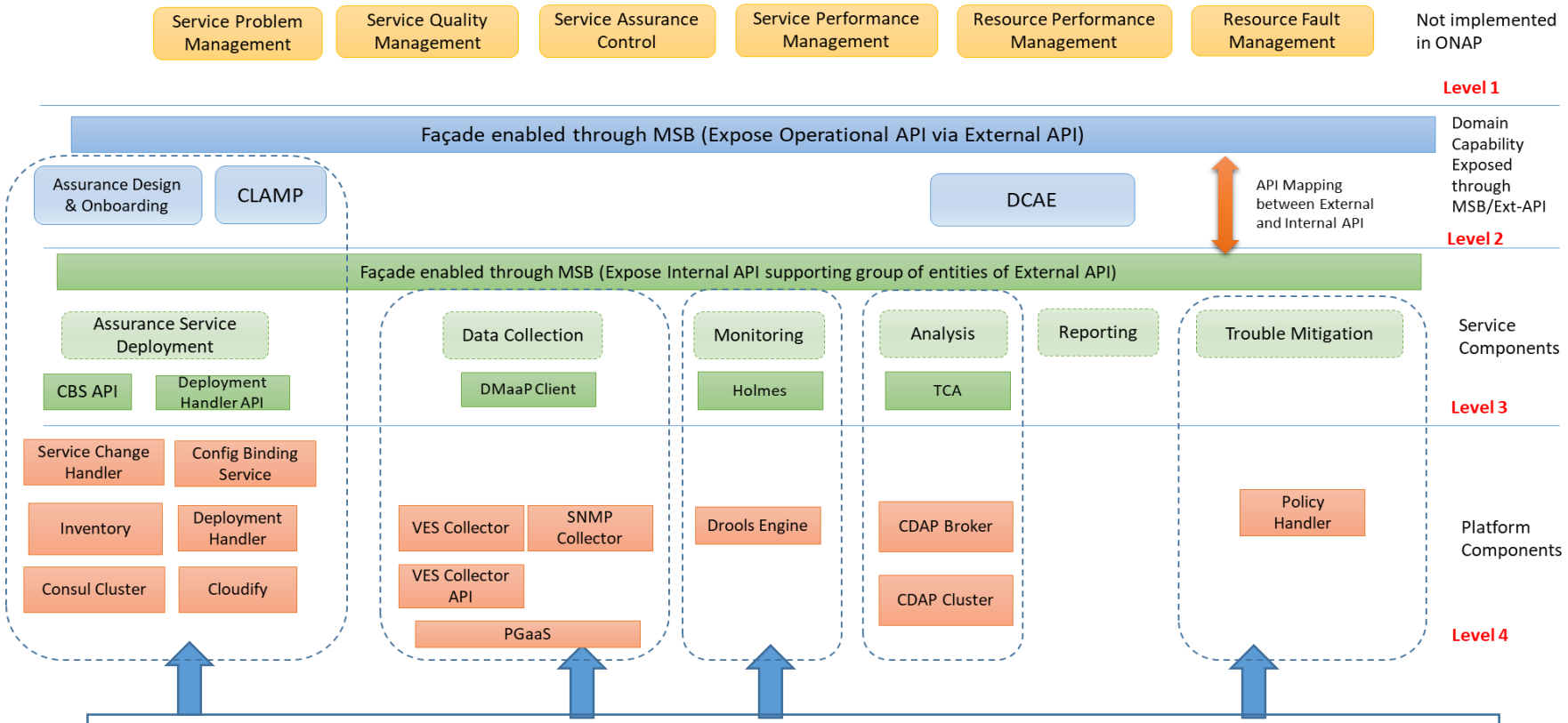


External APIs
TMF , ETSI, MEF, ONF APIs Alignment
Good to have API Gateway here ,
Service Mesh is optional

Support specific entities associated with TMF , ETSI, MEF, ONF APIs
AND/OR
ONAP Internal Feature Level APIs
Good to have Service Mesh here

External API along with MSB is expected to play the role of API mediation between External and Internal API.
Alternatively Service Mesh can be implemented at Level 3 or Level 4 to support API mapping and routing functionality

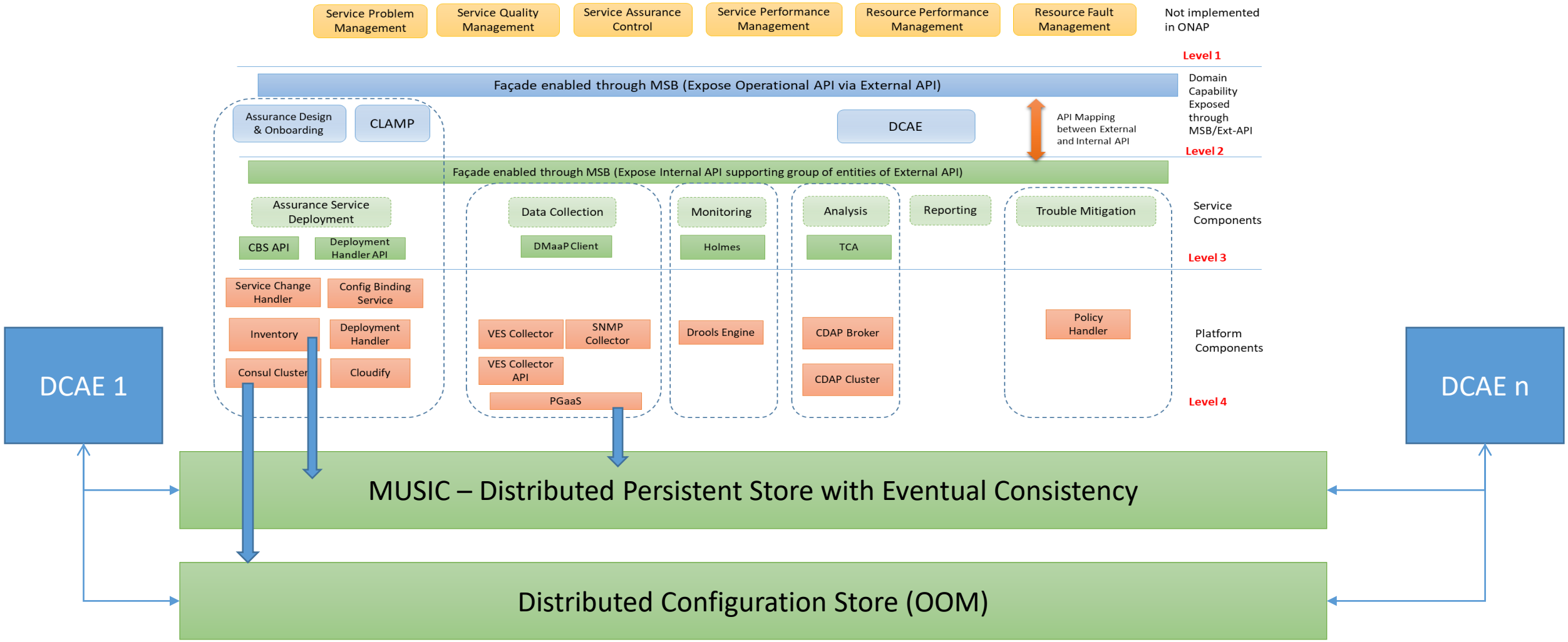
State Handling of Microservice – Example DCAE – Current



To be confirmed with DCAE team !

Potential DCAE functions that maintain states

State Handling of Microservice – Example DCAE – Proposed



- Music has distributed locking mechanism to control processing across different instances.
- OOM already maintains a Consul cluster . This can be reused for DCAE without a dedicated cluster

States - Distributed concerns – What CAP Model ONAP Components Require

- CAP – Consistency, Availability, Partition Tolerance
- CAP Theorem – Only any two properties in CAP can be supported. The properties are selected based on business requirement.
- Saga Pattern or State at Source : Each local transaction within a microservice (that is having own DB to manage state) triggers an event and the dependent services updates the local copy of the state.
- Have common services to support different consistency models across microservices
  - Strong consistency : All provisioning/activation/configuration (mastership), workflow management function
  - Eventual consistency : Monitoring data, Inventory, Topology
- Music supports an eventually consistent store
- Need to identify Microservice functions which require a strong consistency mechanism
- Consistency mechanisms
  - Raft
  - Gossip
- Tools for distributed consistency management
  - Zookeeper
  - Hazlecast
  - Redis

Transaction Support – How MS enable ACID properties

- ACID – Atomicity, Consistency, Isolation, Durability
- Potential areas in ONAP currently using Transaction Model
  - SO interaction with SDNC, VIM driven by workflows (need error mitigation workflows to support atomicity)
  - Closed loop control flow – Need to have separate event handling mechanism to revert any false positive trigger conditions
  - Distributed transactions in an Active-Active HA deployment
- It is a good practice to avoid transaction across microservices especially in a distributed environment
- Use Saga Pattern (described in previous slide). But with caution- it can lead to complexity, cyclic dependency.
- One option for avoiding erroneous transactions is to use two phase commit
- In distributed transactions, to avoid race conditions it is a good practice to use distributed lock with the key assigned to a master

Microservices – Building blocks (Tools to be developed to ease development, ensure consistency)

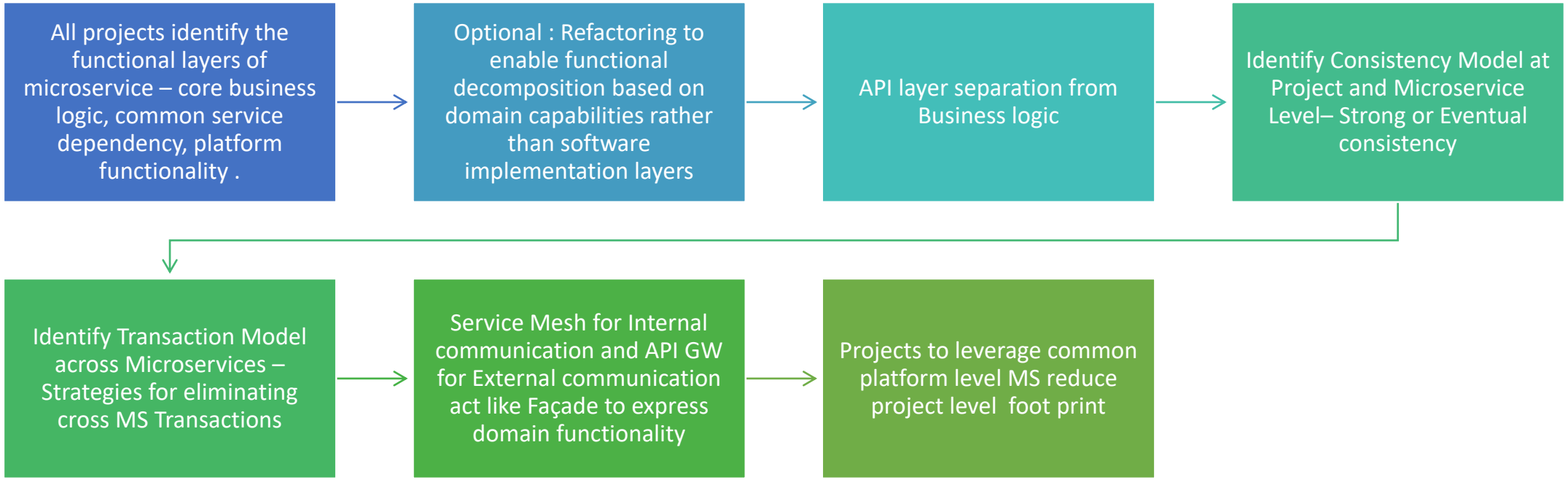
- Potential Options
  - Microservices SDK : Violates independent development concerns, tooling requirement
  - Code generation : Possible – Meta language to be chosen
  - Configuration Templates – Selection of template language, compatibility with different development styles
  - Enforce guidelines : Require tooling – Sonar for example with additional rules
- Suggested Approach
  - Each microservice owner (depending on the layer of functionality) to define APIs as per a predefined guideline – Potential option Swagger
  - Generate code based on Swagger API , MS owner to implement the APIs and register API end point to configuration templates through meta information
  - Configuration templates: Define standard configuration template for MS meta information and dependencies
  - OOM,MSB to read the configuration templates to do wiring between MS

Next Steps

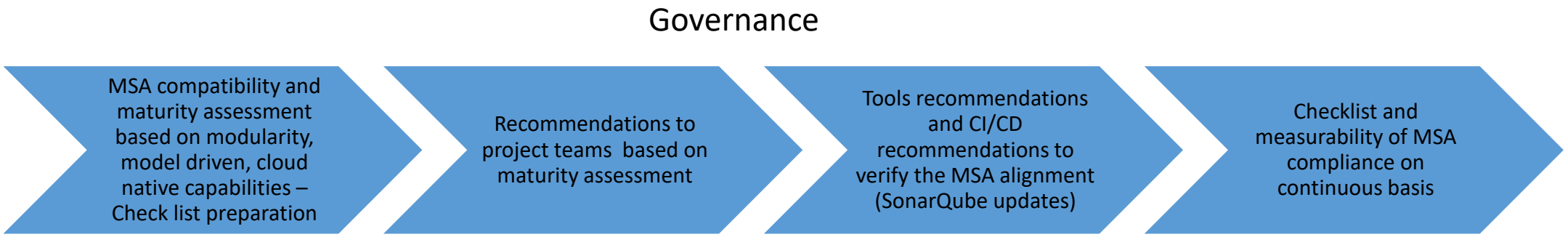
Way forward – Summary

- Short term :
  - ONAP microservices identification from top down functionality point of view rather than project specific microservice grouping
  - Regrouping of microservices to segregate microservices providing domain functionality, common microservices and platform microservices
  - API layer separation from business logic
  - Domain capability enablement through APIs at different levels of micro functionality
  - Architecture/Design review to verify the microservices alignment to overall ONAP level goals rather than limiting to project goals
  - Project teams to come up with strategy to separate domain functions and platform functions
  - Stateless and Stateful MS – Strong and Eventual Consistency Mechanism Requirements – Leverage Distributed/shared storage if possible.
  - Checklist to verify MS readiness across projects
- Long term :
  - Define microservices based on domain functionality , i.e common functionality to be regrouped to a lower level microservice
  - Create a microservice map based on domain functionality which can be used as a capability catalog for operators to pick and choose the specific functionality required.

Initial Recommendations to project teams

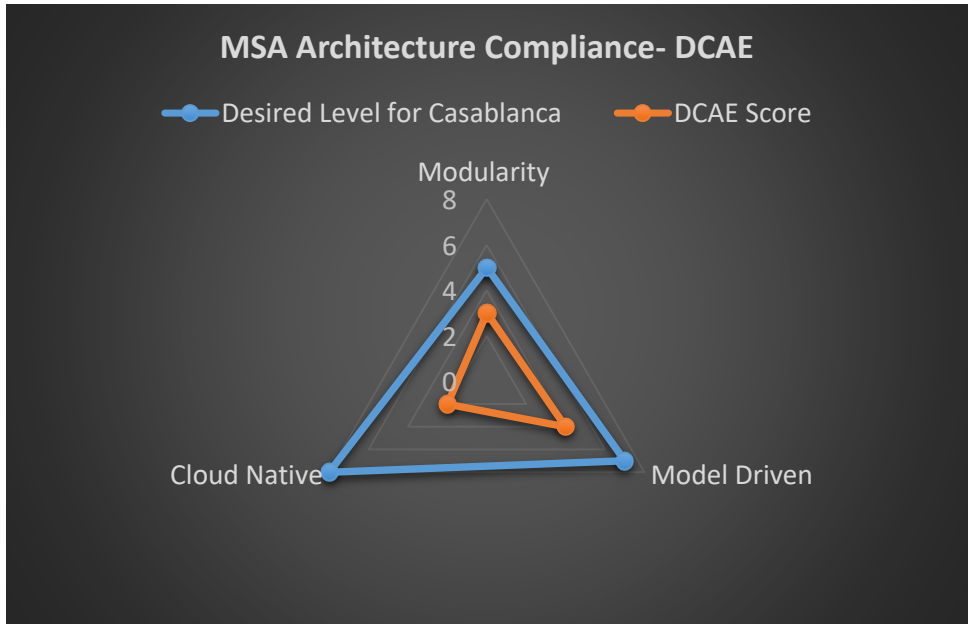


Governance Model & Guidelines



Governance - MSA Enforcement through Objective Measurement

- Checklist to be shared across projects in regular cycles
- Checklist to cover following things to evaluate a projects compliance to MSA
  - Modularity
  - Model Driven Capability Enablement
  - Cloud Native Behavior
- A weighted score of the checklist response to be used as input for certifying projects for MSA Compliance



Guidelines for Projects

Recommendations - Microservice Structural Changes

- Short Term
  - Single responsibility principle – Try not to club multiple functionalities in to single microservices (for example SO)
  - Have the API layer separated from core domain logic implemented by Microservice so that APIs can evolve independently of domain logic
  - Identify stateful services and check the possibility of leveraging DBaaS from OOM or Music
  - Enhance the APIs to have functional capability – for example define APIs to support top down approach , which will support top level service capabilities in terms of managing specific entities.
  - Enable swagger based tooling for consistent API representation and code generation across MS
  - Expand the Microservices API scope to cover Operational, Security and Functional capabilities
  - Identify the domain entities managed by each microservice – domain entities are data elements that represent a domain object. Domain entities are accessed through the APIs.
  - Identify the categorization of microservice – i.e those providing platform capabilities (for example those wrapping specific reusable tools), domain capabilities (i.e those implementing core business logic – for example service decomposition) , and shared capabilities (those supporting the domain capabilities like VIM Adaptors)
  - Reduce cross dependency across microservices through bounded context principles – i.e a domain entity identity changes across the microservice boundaries , let the dependent microservice manage the identities.
  - Use consistent configuration model for microservices – leverage OOM provided Consul if possible
  - Each microservice should be built with fault tolerance capabilities – i.e through high availability enabled through OOM, with capability to regain state after a failure and minimum impact to dependent services. This can be done through replicas in OOM, but state management across instances should be addressed.
  - Follow the Microservices functional decomposition pattern suggested in this ppt – Branded Component , Feature , Function
  - Allow versioning of microservices – from deployment perspective. Identify the impact of two versions running simultaneously
  - Enable portability of Microservices – i.e. Microservice implementation should separate the platform dependent libraries to a common platform layer microservice for easy portability
- Long Term
  - Enabling OOM to provide a catalog of available services from which associated capabilities can be that can be deployed

Recommendations – Microservice Interaction

- Short term
  - Reduce chatty interaction between microservices. Design microservices with low coupling and high cohesion – i.e. reduce inter dependency between microservices and related logic is kept in single microservice
  - Separation of core business logic and intra microservice interaction mechanism – this can be an enabler to support service mesh in the mid term.
  - Avoid all hard wiring between components – i.e do not define dependencies at the code level instead define it through a metadata – this is applicable for API access as well. Example – SDC hard wiring for catalog access (from VFC)
  - For replicated microservices , leverage OOM provided HAProxy, Loadbalancer mechanism or leverage MSB provided load balancer
  - Distributed state management using eventually consistent data store rather than incorporating dedicated logic in microservices
  - Enhancement of Music to generate data change notifications which can be propagated through DMaaP
  - All interaction between microservices to be policy driven with capability to control the interactions from a central service – leverage MSB capabilities and Configuration Policies. Additionally, control interaction between microservices as per meta file that can be enforced by OOM during instantiation of MS.
  - Enable tracing of interaction across microservices – leverage CNCF tools such as OpenTracing. Incorporate this capability as part of Logging
  - Reduce interaction between microservices within a branded component through regrouping of internal dependencies and use Asynchronous communication pattern for all internal communication to avoid long delays. Use REST/HTTP at the external facing MS and use Asynchronous communication (pub/sub) if possible for internal communication. Where ever REST is used support notification mechanism for delayed response. All action invocations between MS is preferred to be asynchronous.
  - Distributed transaction, State management : Enable Saga or State at source pattern – especially for those services that are not using distributed data store. Saga is a sequence of local transactions where each transaction updates data within a single service, first transaction is initiated by an external request then each subsequent step is triggered by the completion of the previous one which is notified by an event.
- Long Term
  - Move towards event driven microservices – i.e state stored in a distributed eventually consistent data store and any change in state triggers a notification to subscribed microservices which act upon change in state

Recommendations – Microservice Operational Changes

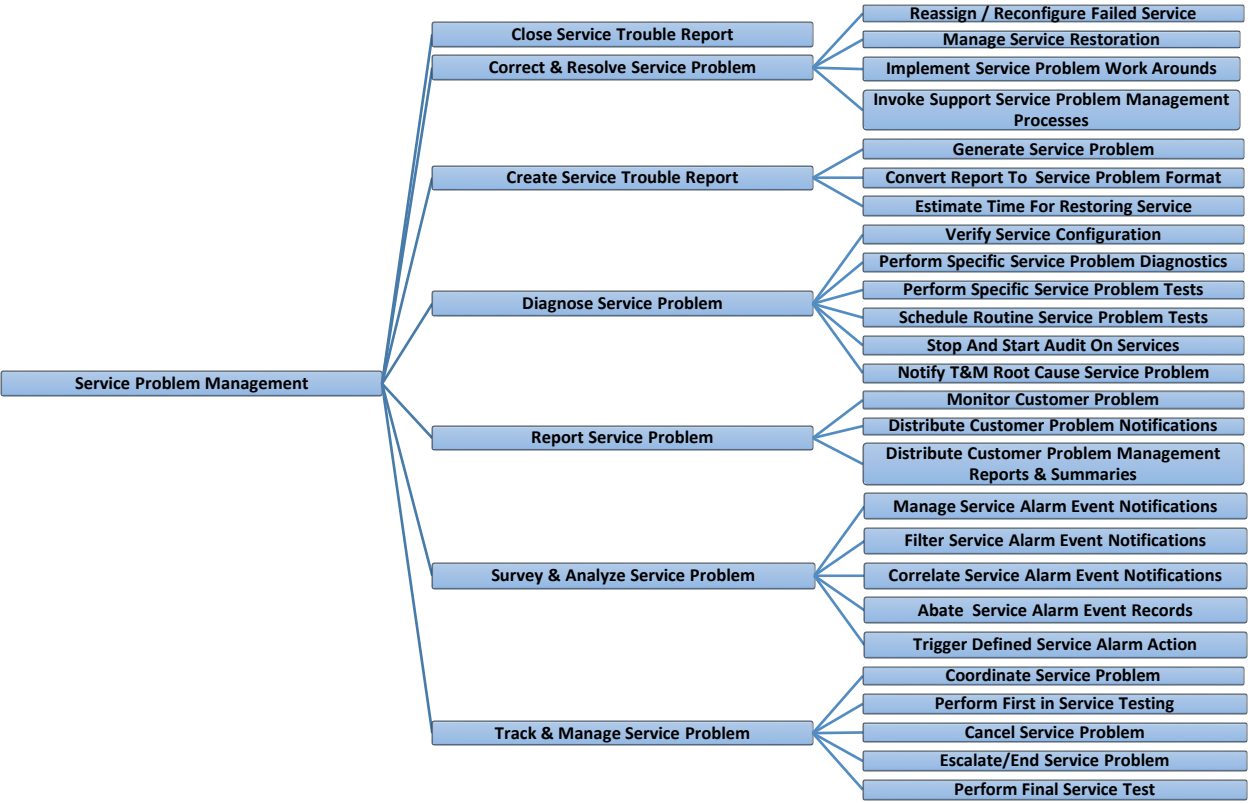
- Short Term
  - Microservices interdependency to be represented in a meta file for the OOM system to bring up MS in sequence
  - Microservices capabilities and associated API end points to be represented through metafile for OOM to register the capabilities with MSB . Currently component level end points are registered, instead functional capability driven endpoint registration to be supported
  - Configurations of microservices to be represented in a consistent manner and not hard coding should be encouraged
  - All point to point interaction to be blocked and all interaction to be driven through MSB, API Gateway or DMaaP which are controlled through access policies
  - Follow the layering pattern suggested in this presentation for mapping Services, Deployments, Pods and containers
  - Project teams to understand the Pod and container concept used by K8S – all related cohesive functionality to be grouped under a Pod. Currently each container is mapped to a Pod. Project teams to regroup their functionality that need to fit into a Pod
  - Project teams to identify the impact of multi-tenancy in ONAP – i.e ONAP deployment shared by multiple operational tenants. This will lead to different instances of MS Pods to be deployed in the cluster. Identify the functionality that can be shared across tenants. Follow the platform , common functionality , business logic level grouping for low impact to support tenancy
  - All the inter MS interactions to be controlled through RBAC and associated policies.
  - OOM : Enable selective installation of capabilities by having a catalog of capabilities to choose from which maps to associated microservices deployments – dependency resolution to be done automatically
  - OOM: Support different flavors of deployment – x node cluster, single machine, distributed clusters etc.
  - OAM dashboard for Microservices – with potential Prometheus integration

Recommendations – Enablers for MSA – Tools , Techniques

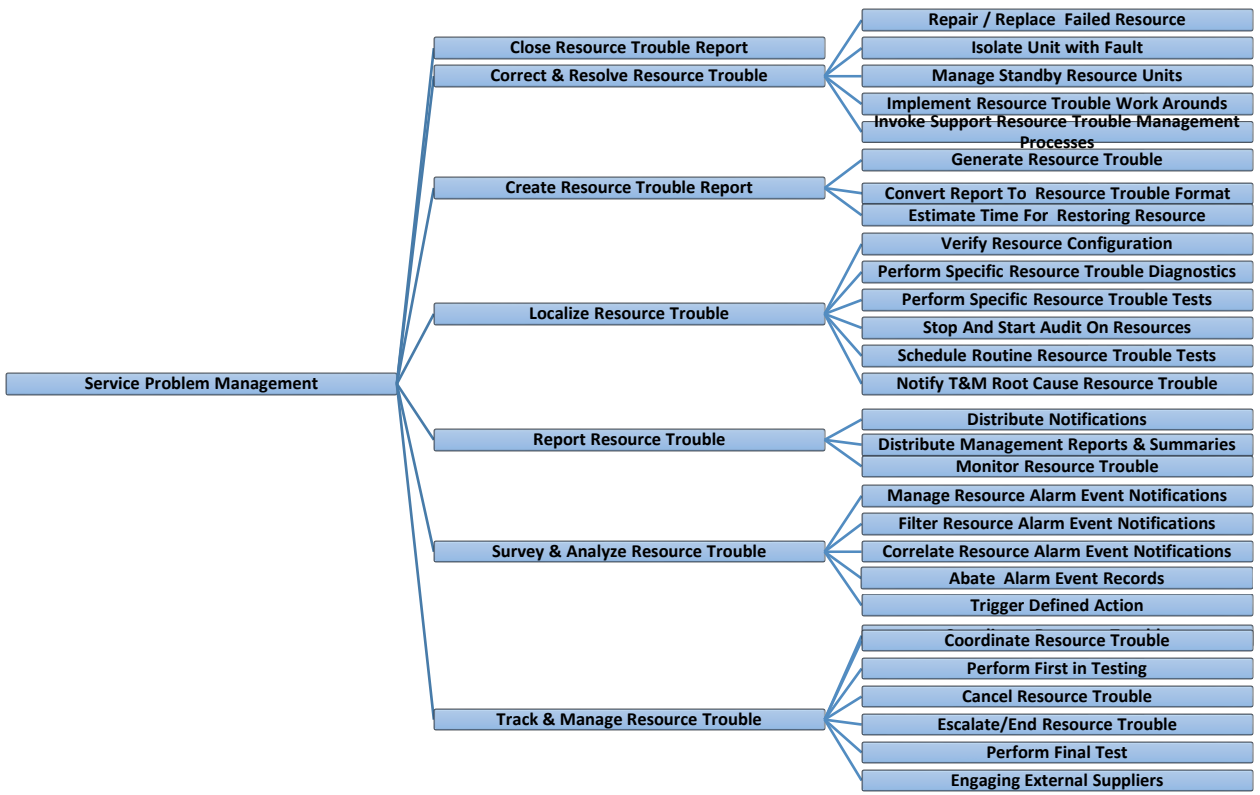
- Swagger metadata and associated code generation for consistent representation of APIs
- Microservices health monitoring
  - Prometheus
  - Log tracing using CNCF toolsets
- Cloud native tool sets
  - Refer to a separate analysis done by Tiger team
- Template tools (Data mapping)
  - For model mapping from one format to other – Jinja2, Velocity etc.
- SDK tools
  - Eclipse custom plugin developed for microservices
  - Maven archetype for microservices project structure with DMaaP client , MSB client, Consul based configuration template etc
- Tools for consistency and state Replications
  - MUSIC
  - Zookeeper
  - Redis
  - Hazelcast
- Sidecar and service mesh
  - Refer to separate analysis done by Tiger team

Thank You

Trouble to Resolve : TMForum recommended decomposition



Service Trouble Management



Resource Trouble Management