HEALTHCARE SYSTEMS

MINIMUM VIABLE PRODUCT - ARCHITECTURE DESIGN

ACCESS Health Digital
digital.health@accessh.org

About Us

About ACCESS Health International

ACCESS Health International is a think tank and advisory group. We believe all people have right to access high quality, affordable healthcare

We have 5 Country offices across the globe.

About ACCESS Health Digital

ACCESS Health Digital works as a strategist for all digital health initiatives of Access Health.

AHD expertise lies in supporting and building a harmonized digital health ecosystem to achieve Universal Health Coverage by opensource innovative healthcare systems and by leveraging cross-over skills between healthcare and technology.

DIGITAL HEALTH | INDIA'S POLICY JOURNEY SO FAR….

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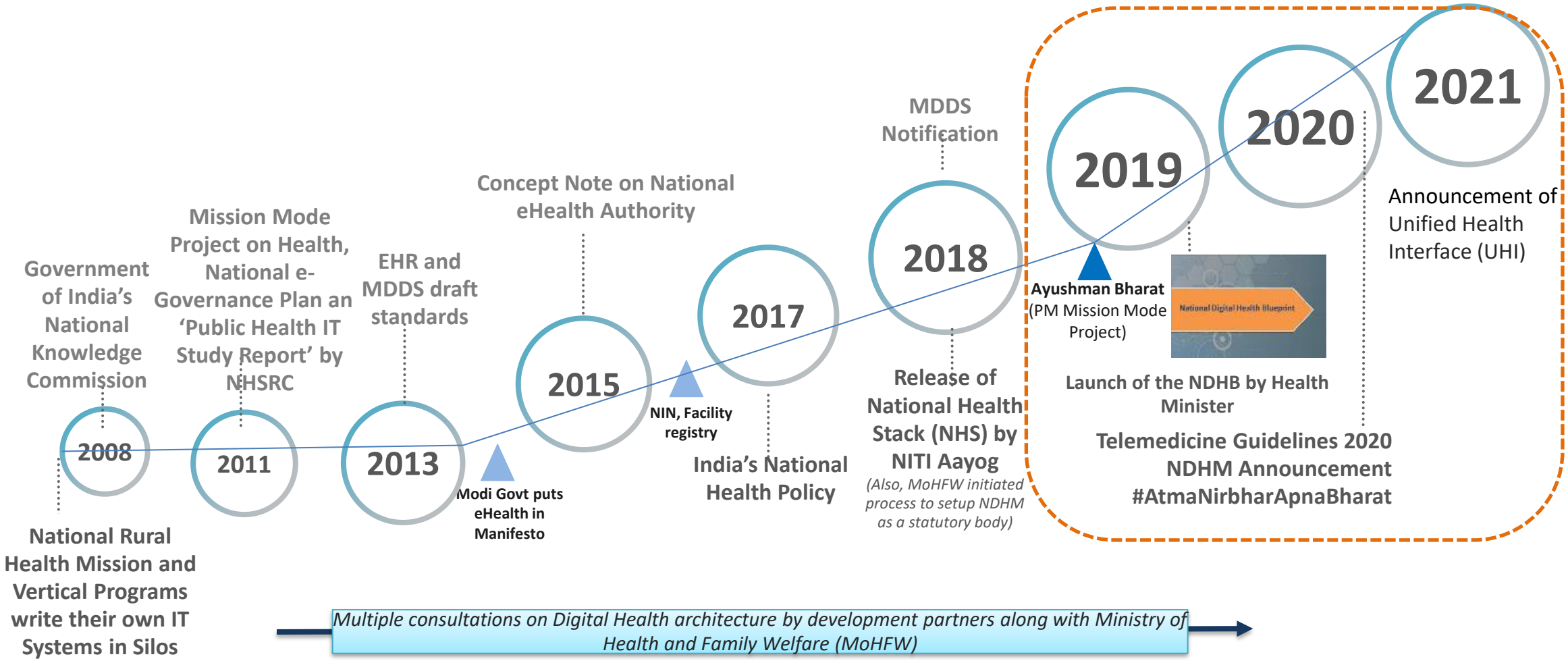
Over the past few years, in addition to analyzing global best practices, conducting landscape assessments, considerable consultations were conducted with relevant stakeholders at the center / state, academia, private sector.



DIGITAL HEALTH | ACCESS Health Digital JOURNEY SO FAR….

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Oct 2018

Prof. Dennis Streveler & Dr. Pankaj Gupta wrote **eObject concept** for the Book "Health System for new India

Aug 2019

Launch of the NDHB by Health Minister

Nov 2019

The book "Health System for New India" was published by NitiAayog

Jan 2020

MoU signed with NHA

national health authority

Feb 2020

Defined HCP processes & E-Object specifications

March 2020

E-Objects were referenced extensively in Johns Hopkins book "Information Technology for Primary Healthcare in India"

April 2020

Lead Experts on NHA vision document on "Data & Insights Hub"

April 2020

Openbodhik.in & GitHub was created as an opensource knowledge & code base

Openbodhik.in

GitHub

May 2020

Started work on SEA-MAP Partnership

2021

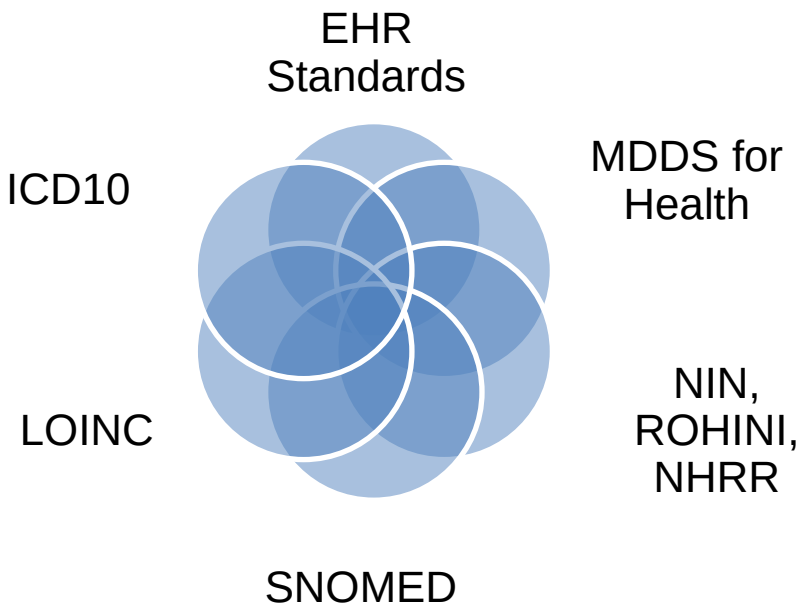
Provider Working Group Report

Lab Special Interest Group

AHD Academy

National Drug Index SIG

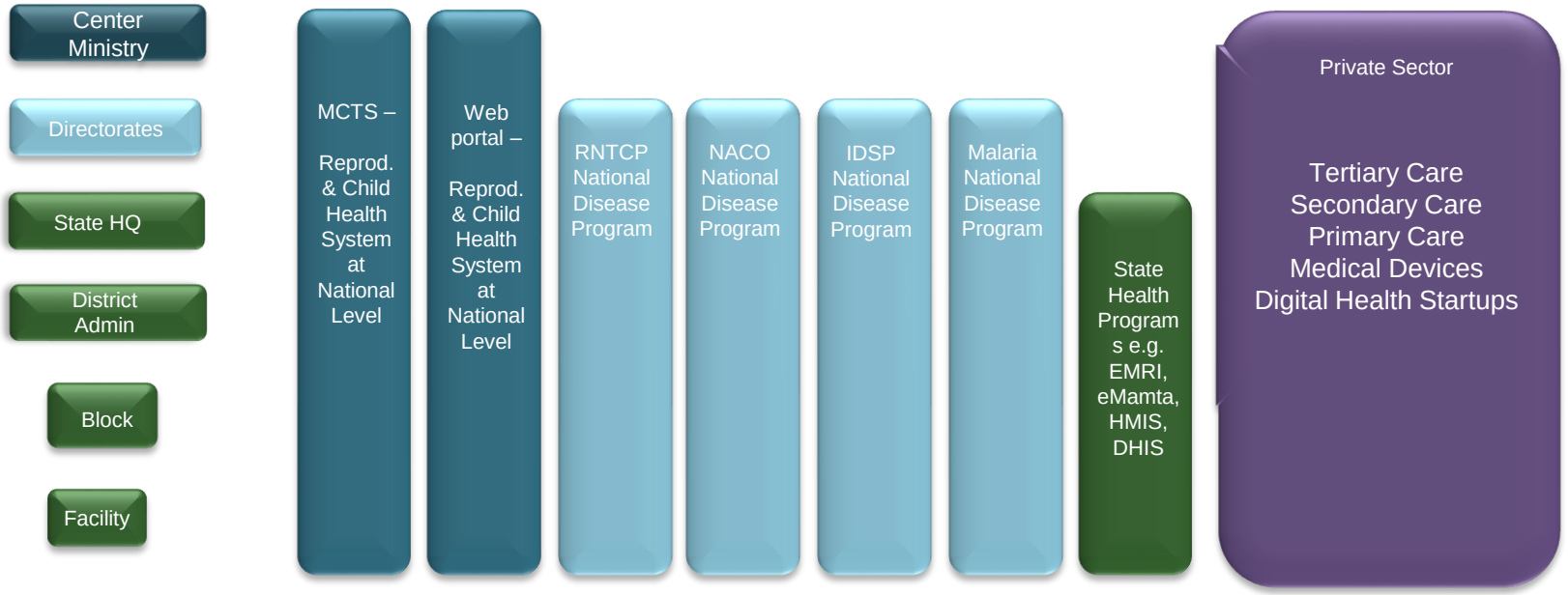
INDIA has Implemented Standards* In Isolated Fragmented Pockets



** Implemented since 2018*

Health Systems | Current Landscape

Siloed data systems across public and private sector in the country, with no data standards followed

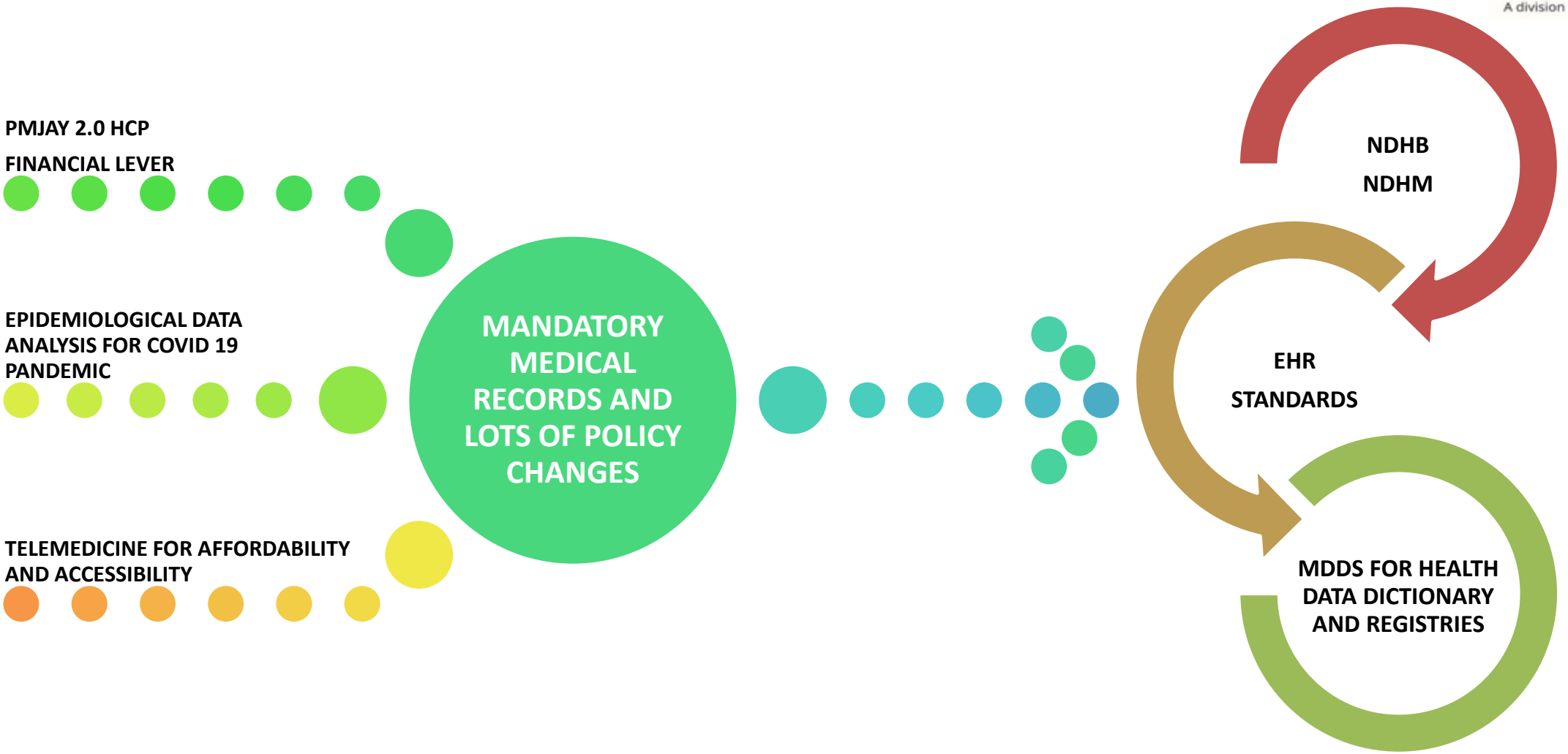


Need of the hour is to adopt

NDHB recommended Standards like MDDS for demographics and LOINC for Investigations.

For Semantic Interoperability, standard formats and metadata for efficient data exchange of encounter, episode, prescription, discharge summery, etc should be used.

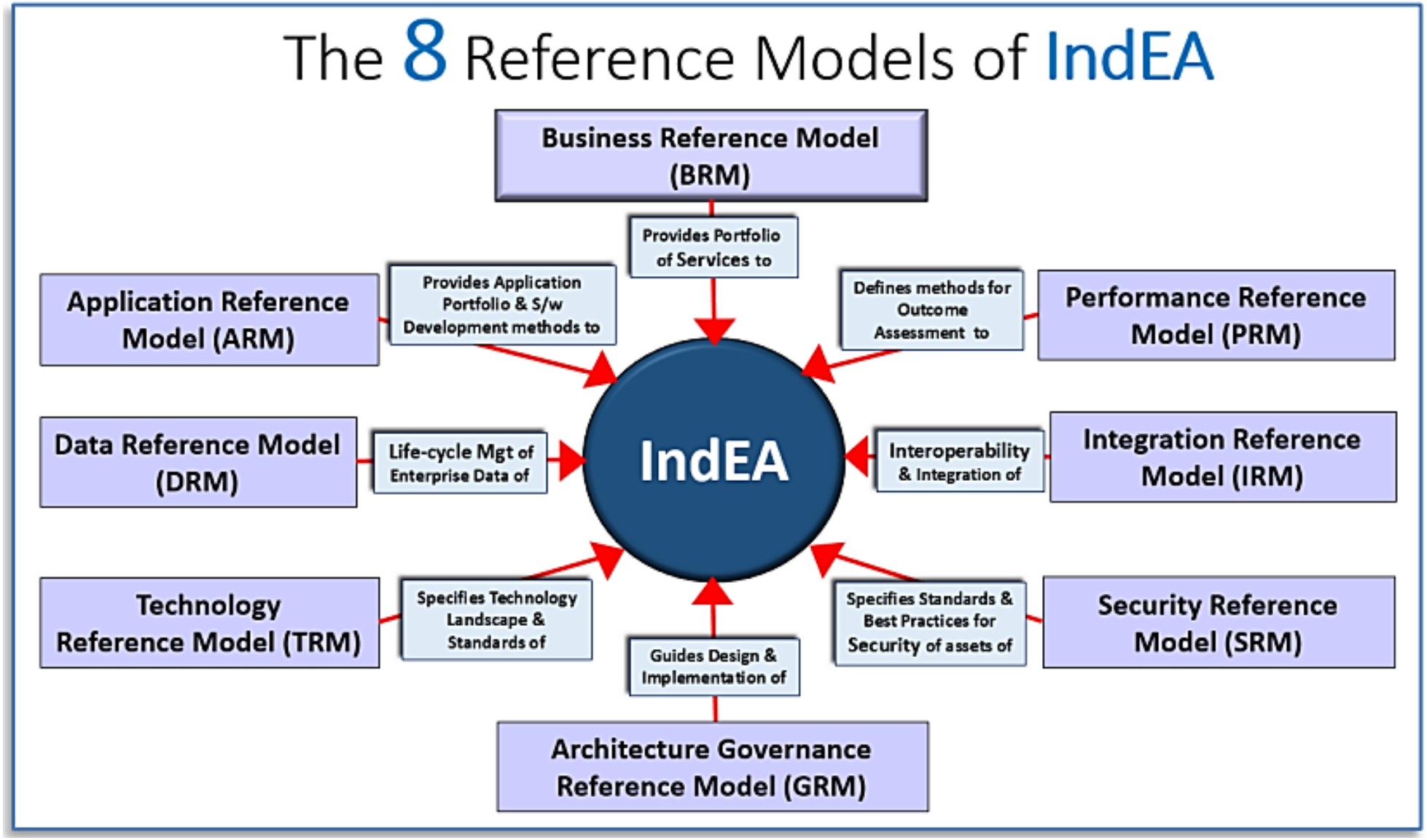
Digital Health | Policy & Market Updates



- ***Telemedicine guidelines*** released in ***April 2020***. These will ***ensure an accelerated adoption of NDHB*** based standards
- ***National Digital Health Mission announced in May 2020*** as part of the Government's response to the Coronavirus Pandemic. The mandate is to ***operationalize, execute and implement the National Digital Health Blueprint.***

IndEA Architecture

IndEA framework | Reference models



IndEA | Application Reference Model

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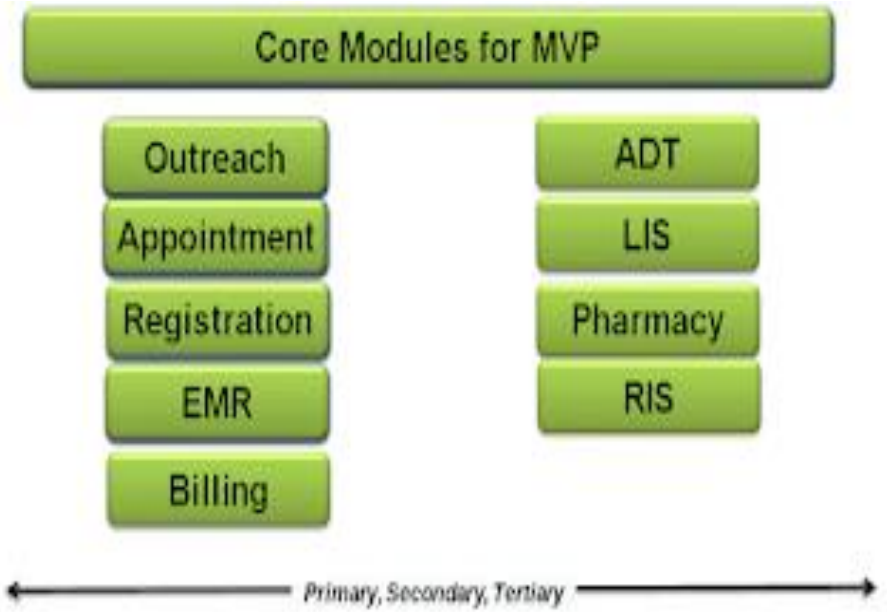
ARM captures guidelines and recommendations on **Application Architecture Standards**, use of **Open APIs**, **Microservices Architecture** and **Open-Source Software**.

HDIS MVP Microservices Published in GitHub



The first set of released microservices includes infrastructure microservices which serve as a base for setting up a microservice development environment.

How can the digital health Opensource community benefit from these microservices codes?

1. **New product development** - If you are planning to build a new product, it is recommended to build he solution on microservices architecture using the shared microservices.

2. **Legacy application** - If you have a Legacy system and you don't want to disrupt your ongoing business model then you have an option of building a Bolt-On a translator layer on top of the Legacy system such that it populates the eObjects.

IndEA | Non- Functional Requirements

Graceful Failure

• The application must not have any Single-point of failure. There must be a graceful degradation of services in case of any failure

Scale Elastically

• The application should be able scale elastically to handle the increase or decrease in workload

Handle Volume

• All applications must be able to handle volume of X% Y-o-Y growth for the life of the application

Support Scaling

• The Application must support horizontal and vertical scaling of Servers, compute, storage, network etc.

Support load

• The Application must support load balancing and routing

National Digital Health Blueprint- Quick Overview

National Digital Health Blueprint (NDHB)

*Released Standard Nov 2019

Ecosystem, Not system

National Digital Health Eco-system (NDHE), Federated Architecture based on IndEA Stack, Health Information Exchanges – '**Think Big, Start Small, Scale Fast**'

Principles & Building Blocks

Minimum viable set of **35 building blocks, and more can be defined..**

Applications & Digital Services

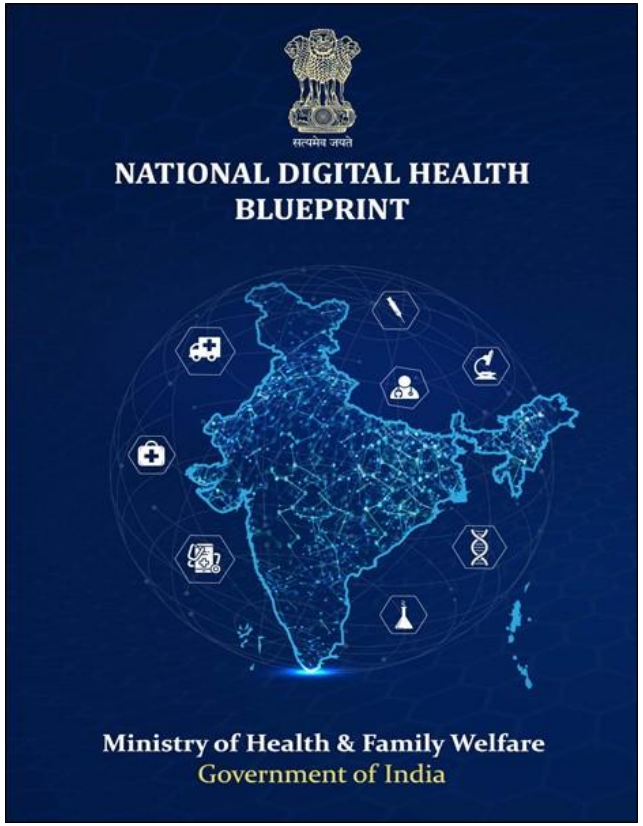
Evolve and develop **thematic areas for development and deployment** of applications

Standards

Minimum viable set of standards, for semantic interoperability: EHR, MDDS, NIN, SNOMED, FHIR..

Institutional Framework

Establish **National Digital Health Mission (NDHM), govt. organization** with complete **functional autonomy**



"The NDHB forms the foundation on which the edifice of an entire National Digital Health Eco-system can be built in a phased manner."

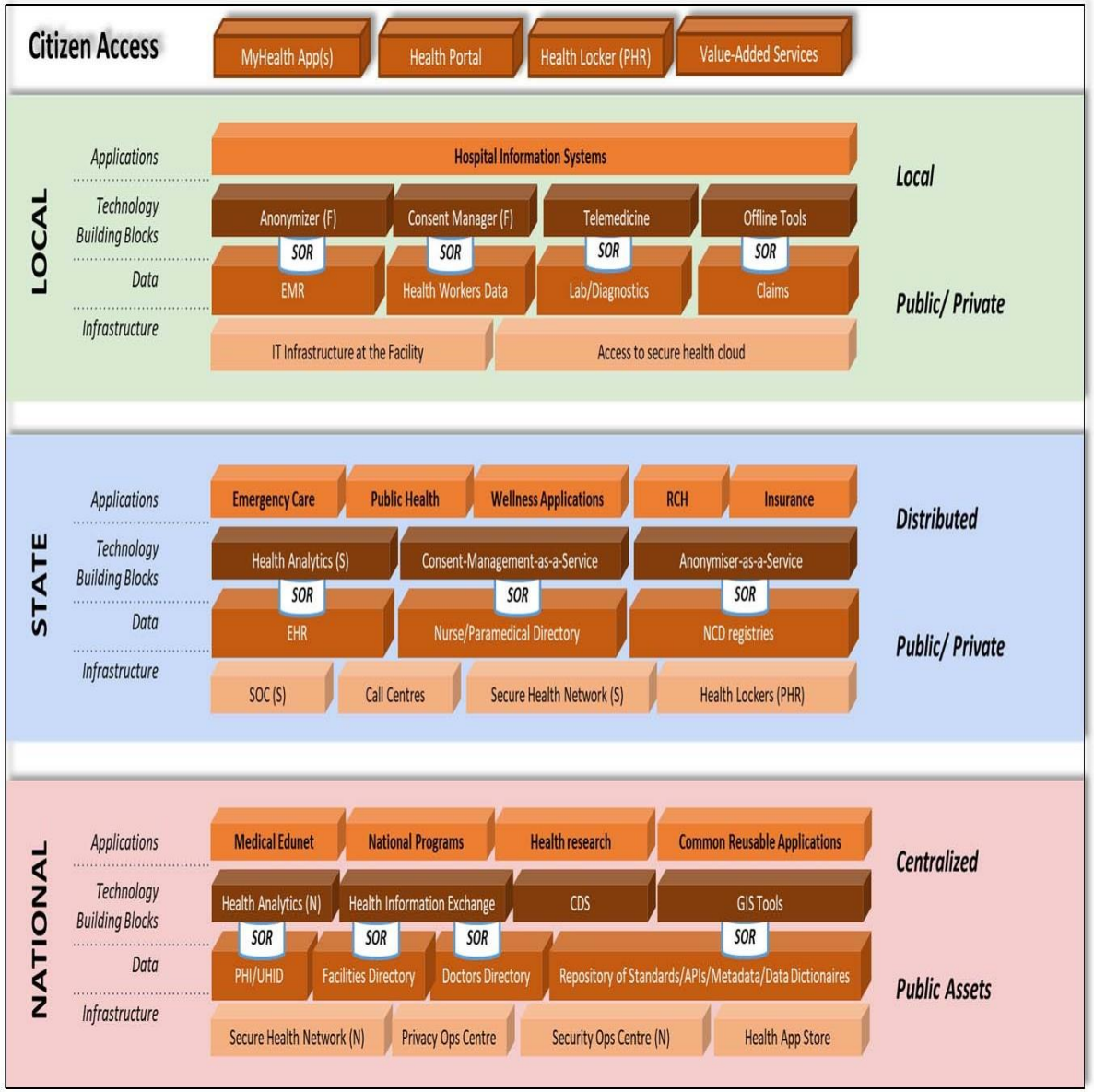
- J. Satyanrayana, Chairman, Committee on National Health Stack

NDHB | Design Principles

NDHB Design Principles	Federated Architecture	Microservice Architecture	Privacy & Security
• Registries as Single source of truth for data • Mobile First Design strategy • Open standards based Building blocks • Interoperability • Minimalistic Design with Scale Fast Approach • Patient control over his records • Continuum of care	• Health Data fiduciary at local and state levels with central Data lake for indicators • EHR and PHR for Health data exchange • FHIR based open API for interoperability • Unique Identification of entities • Common meaning of data	• API based model • Domain driven design based decomposition of business concerns • Scalability, Maintainability, Resilience, Loose Coupling by design • Continuous Delivery and light container (Docker and Pods) based Deployment (easy DevOps) • Easy integration with existing Monoliths	• Data Privacy, security and integrity by design • Controlled Data Visibility and Consent Based Data Sharing • Data Provenance • Physical security • Network security

*Ensure Compliance by conducting a **Standardization Testing and Quality Certification** (STQC) or STQC like audits*

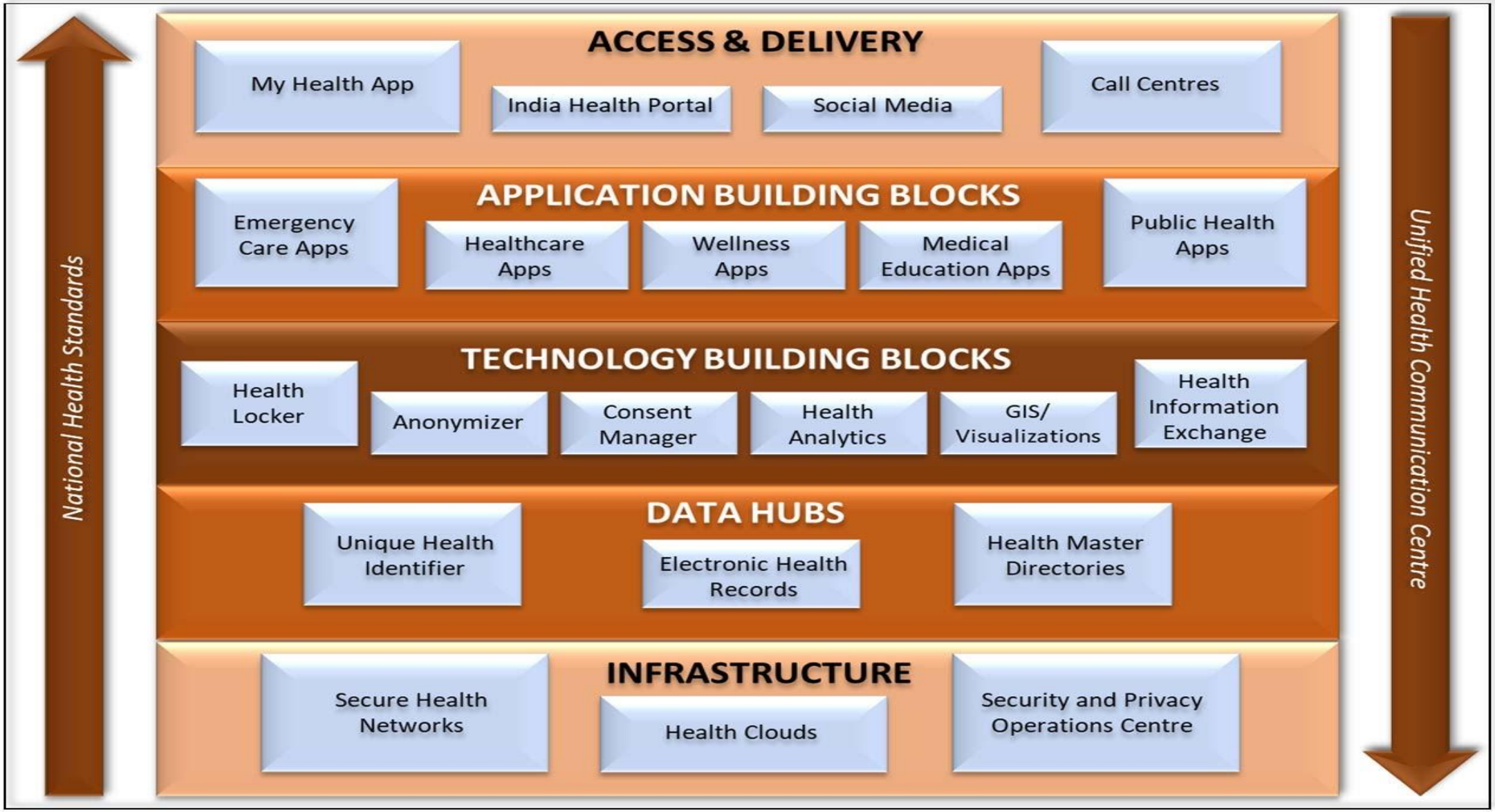
NDHB | Overview of Federated Architecture



Principles of Federated Architecture

- **3 levels** – National, State and Facility levels for all digital health data and applications
- **Patient data** held at the Point of Care or closest possible physical location
- **Citizen shall be in full control** of the 'processing of health data' relating to him/ her
- **Systems of Record (SoR)** shall hold the primary data and all other IT systems, applications or entities will have access to it only through links, subject to the applicable permissions and consent.
- Large facilities and government health departments shall be **data fiduciaries**. Small facilities will perform the role of data processors.
- Data fiduciary shall be responsible for the **data protection obligations and compliances under the applicable laws**

NDHB | Building Blocks



NDHB | Recommended Standards

Purpose	Recommended Standard
Consent Management	ISO/TS 17975:2015 Health Informatics - Principles and
Consent Framework	Electronic Consent Framework (Technology
Structured Clinical information exchange	FHIR Release 4 (subject to section 3.4.2) (with any future errata(s))
Still Images / Documents Audio / Video	Still Image: JPEG Document/ Scan: PDF A-2 Audio: MP3 / OGG Video: MP4 / MOV (embedded as Binary Content in relevant FHIR resource)
Diagnostic Images (Radiology including CT, MRI, PET, Nuclear Medicine / US / Pathology), Waveforms (e.g. ECG)	DICOM PS3.0-2015c (embedded as Binary Content in relevant FHIR resource)
Terminology/ Vocabulary	SNOMED CT- (for all clinical terminology requirements in health records)
Coding System	WHO ICD-10- (for statistical classification of diseases and related health problems) LOINC-(for observation, measurement, test-panels, test items and units)
Security	Digital Certificate, TLS / SSL, SHA-256, AES-256
Access Control	ISO 22600:2014 Health informatics - Privilege Management & Access Control (Part 1 through 3)

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MDDS for India- Introduction & Usage of MDDS Code Directories

META DATA AND DATA STANDARDS FOR HEALTH (MDDS)

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MDDS - ***Health Data Dictionary [HDD]*** *for India for* *semantic interoperability.*

**Drafted in 2013-2014, Notified Standard since Aug 2018*

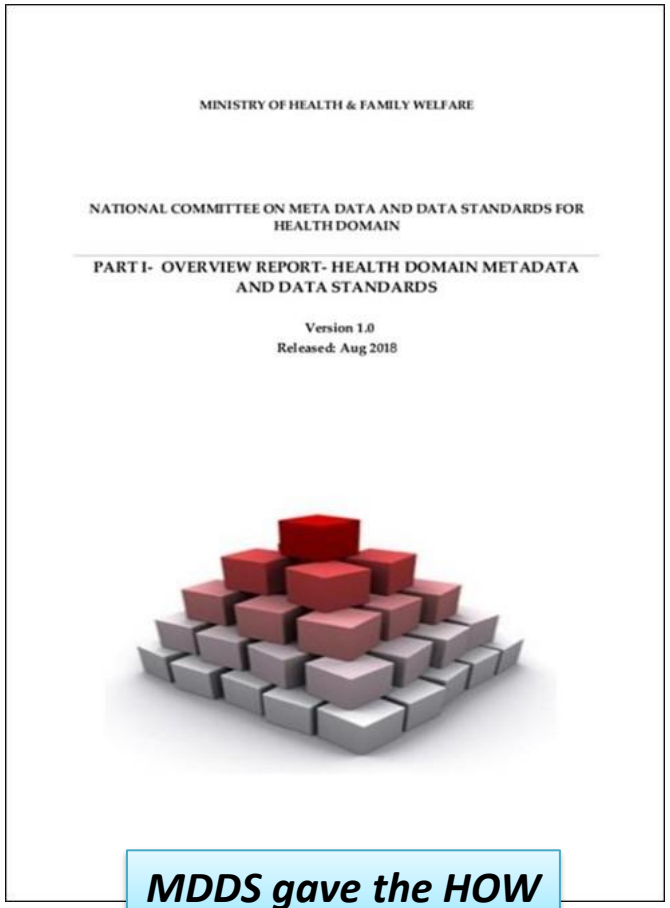
1. Library of 1000+ Data Elements,
2. 140+ Code Directories
3. Registry Design
4. Health Information Exchange Concept
5. Governance

DATA ELEMENT
XXX

DATA TYPE,
DATA SIZE,
VALUE SETS,
CODE DIRECTORIES

Common meaning conveyed by different code sets

लिंग	Gender	பாலினம்
X	MALE	1
Y	FEMALE	2
Z	TRANS	3
	OTHER	4
System 1	HDD	System 2


MINISTRY OF HEALTH & FAMILY WELFARE

NATIONAL COMMITTEE ON META DATA AND DATA STANDARDS FOR HEALTH DOMAIN

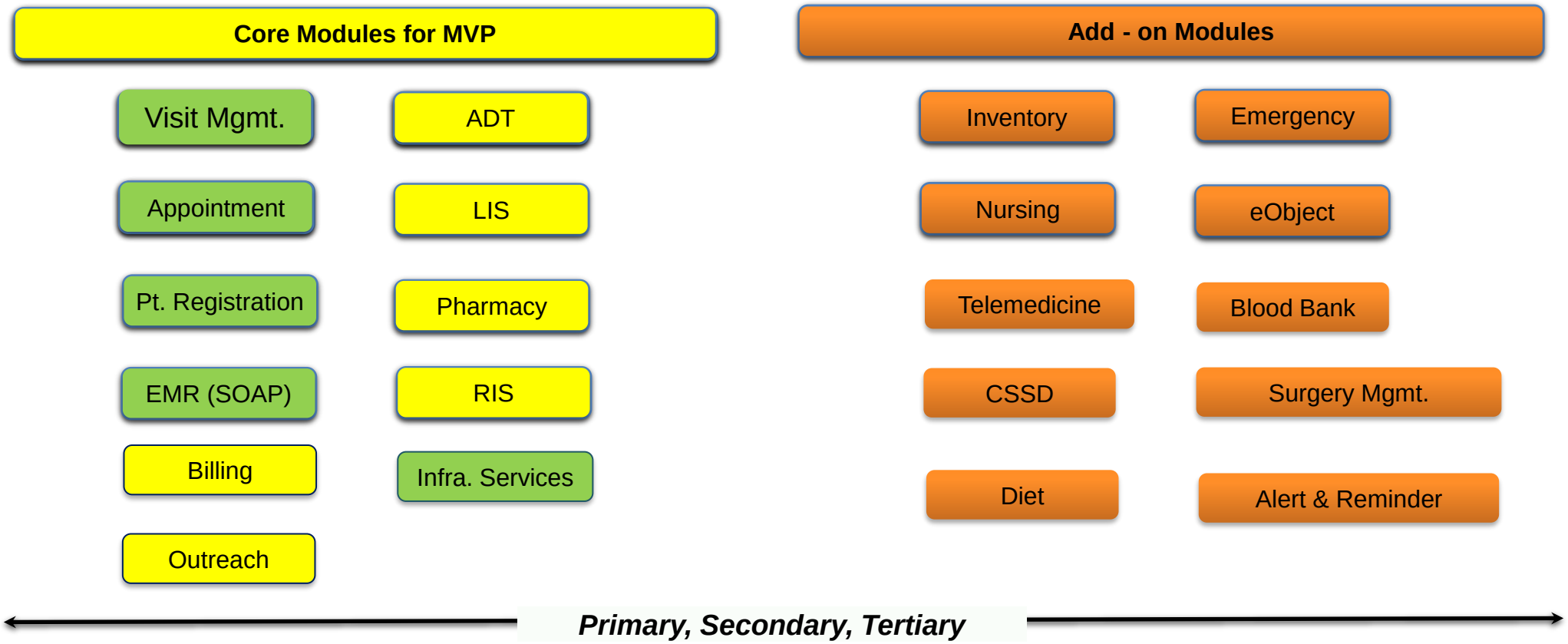
PART I- OVERVIEW REPORT- HEALTH DOMAIN METADATA AND DATA STANDARDS

Version 1.0
Released: Aug 2018

MDDS gave the HOW

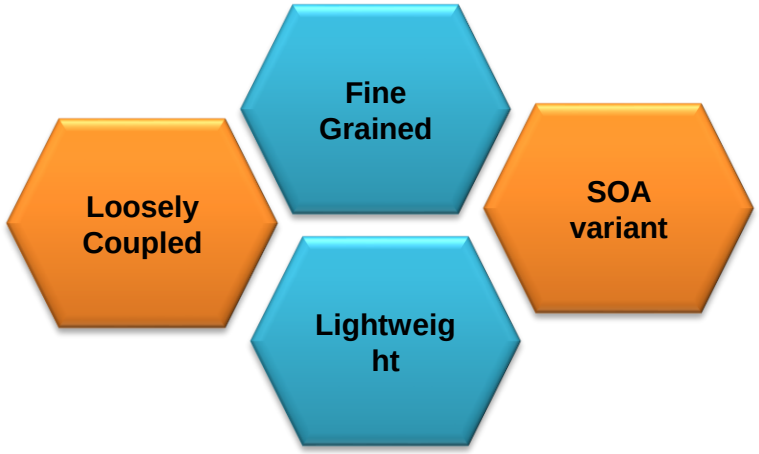
Microservices for HDIS MVP- Recommended For New Product Development

Minimum Viable Product [MVP] Modules

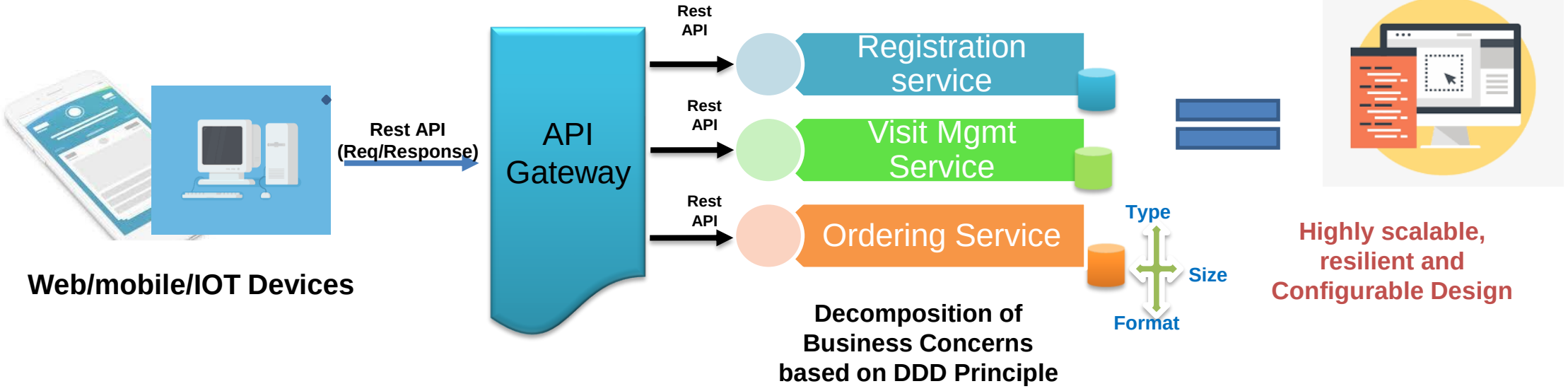


The core blocks above are representation of minimum functionality sets (also known as Minimum Viable Product Modules) within HDIS universe. All these core modules are required functions that any healthcare ecosystem will need. There can be add-on modules, but the core are the minimum that must exist in a healthcare system. These modules caters not only the hospitals but also public health delivery centres like PHCs, SCs, HWCs, Dispensaries, Pharmacies of private etc. But a PHC might not need full set of core functionality rather a subset of these MVP modules.

What is Microservices Architecture?



Microservice Architectural style is an approach to developing a single application as a **suite of small services**, each running in **its own process** and **communicating with lightweight mechanisms**, often an HTTP resource API.



What is Microservices Architecture?

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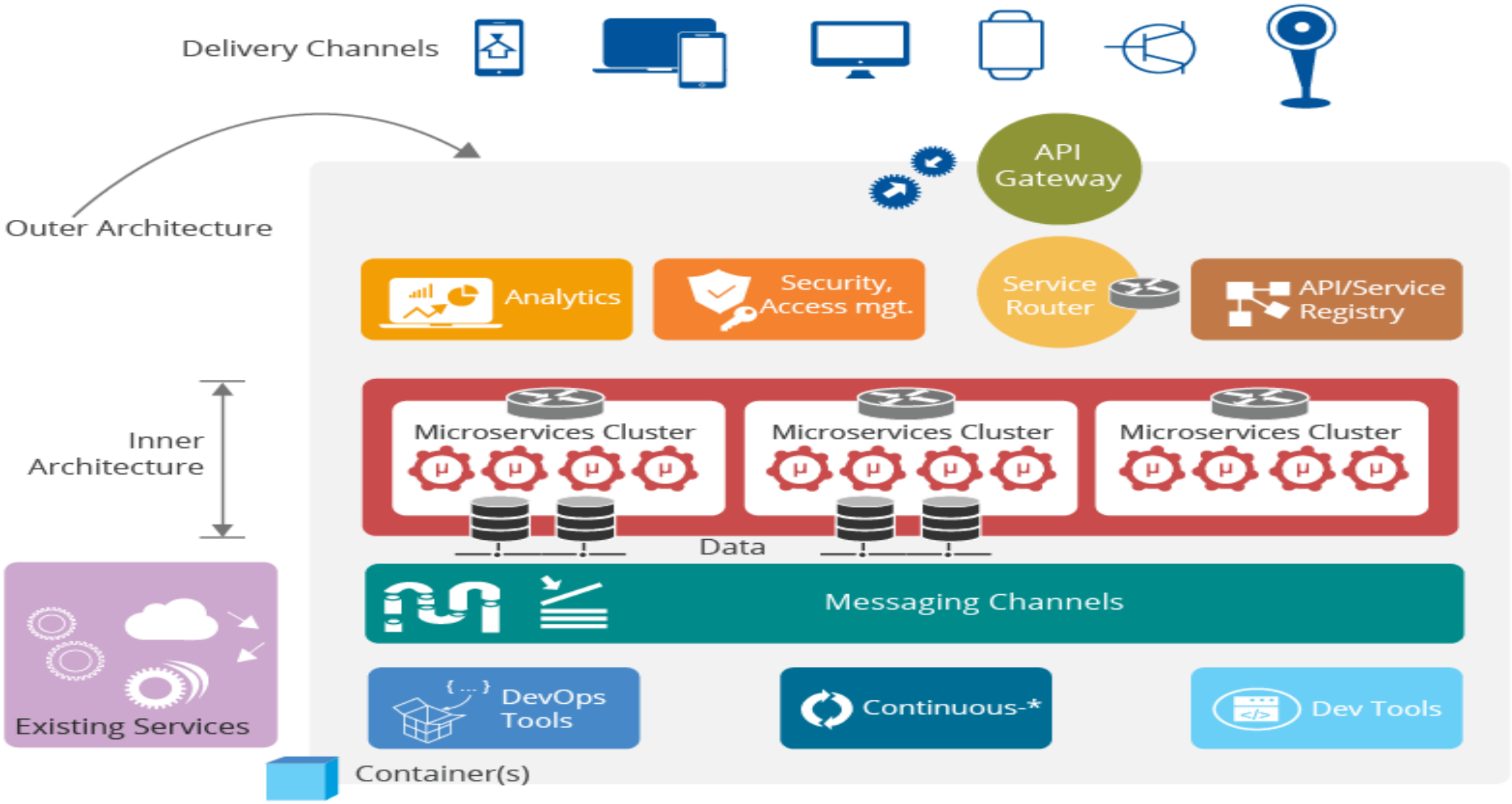
- Small and Focused on one Business Functionality (Domain Driven Design)
- Functional & Team Scaling (Independent Development, Release and Deployment)
- Compliance to NDHB Standards
- Fault Isolation vs. Bring all down
- Well defined Module boundaries across domain functionalities with explicit interface declaration
- Rewrite can be limited to one service
- Polyglot Persistence (Decentralized)
- Decentralized choreography vs centralized orchestration
- Loosely Coupled Maintainability, Reliability, Extensibility, Scalability

Microservices Architecture | Detailed Layout



Technical Approach: Microservices Architecture & its Implementation

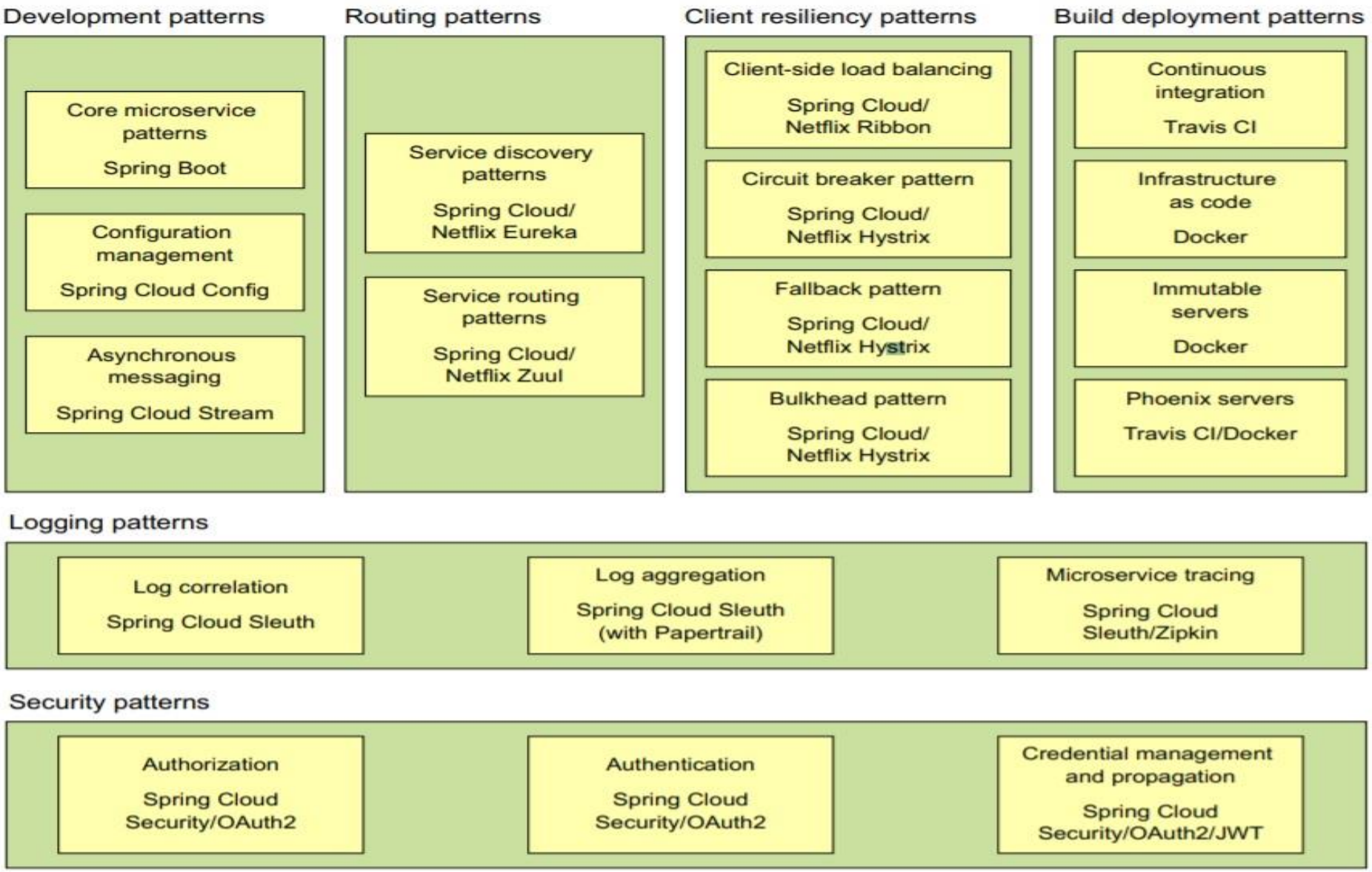
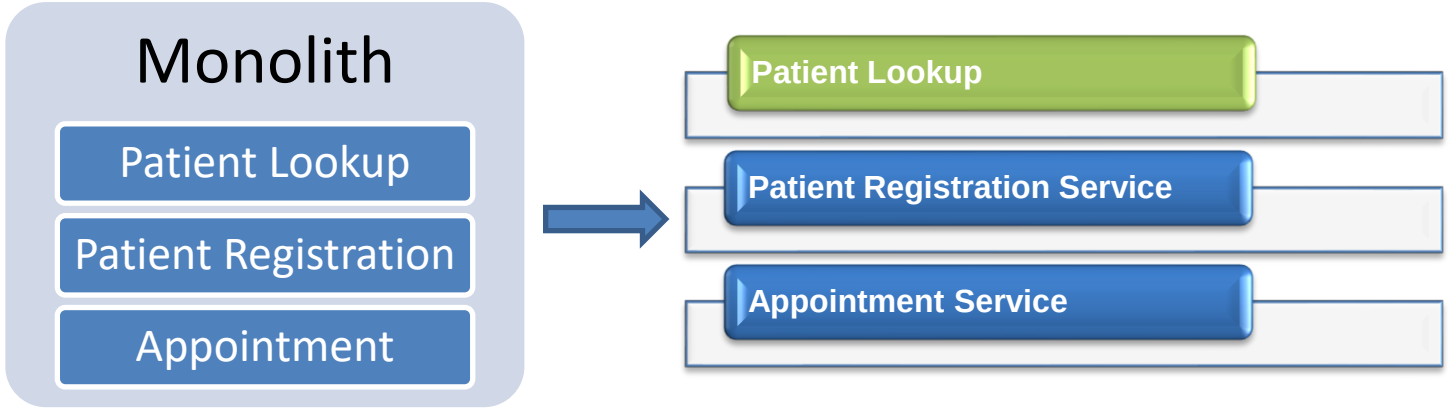


Fig. Technical Architecture: Microservice

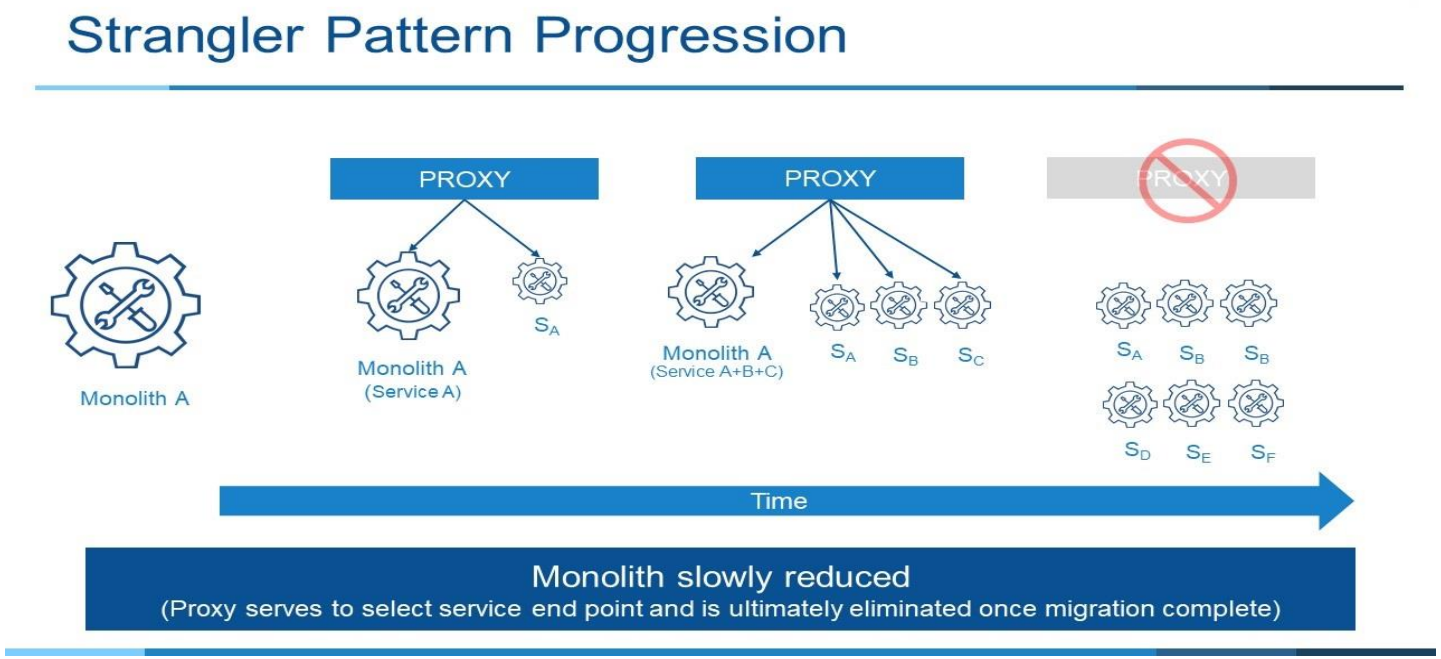
Technical Approach: Microservices Architecture & Its Implementation

1. ***Decompose your monolith into smaller services.***

   Prioritize and finalize the simplest function/module to strangle to avoid the risk

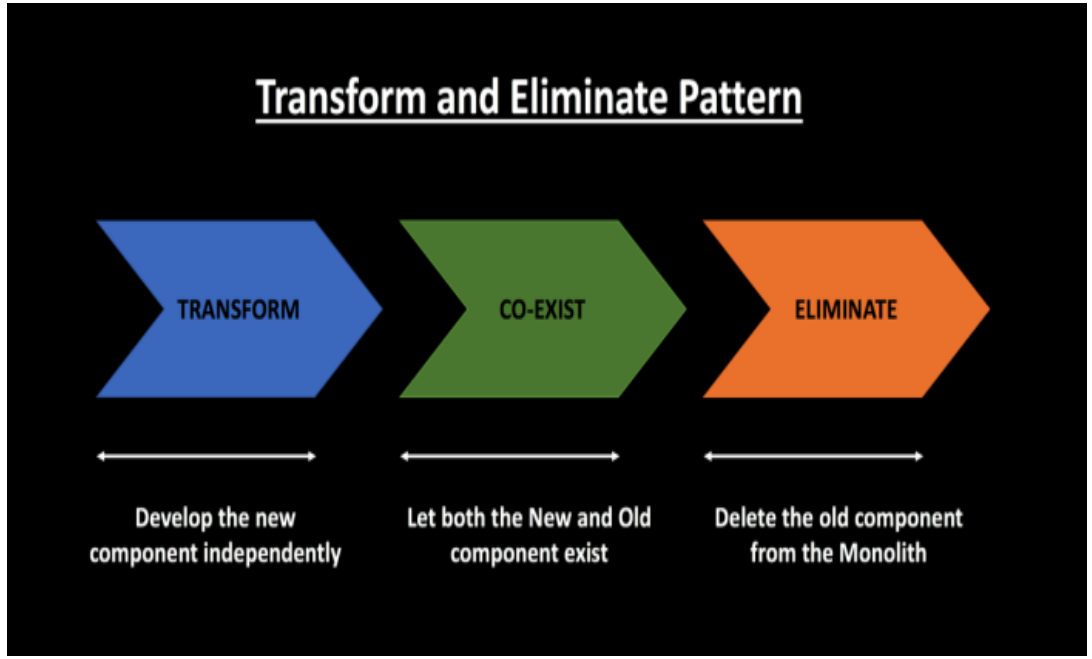


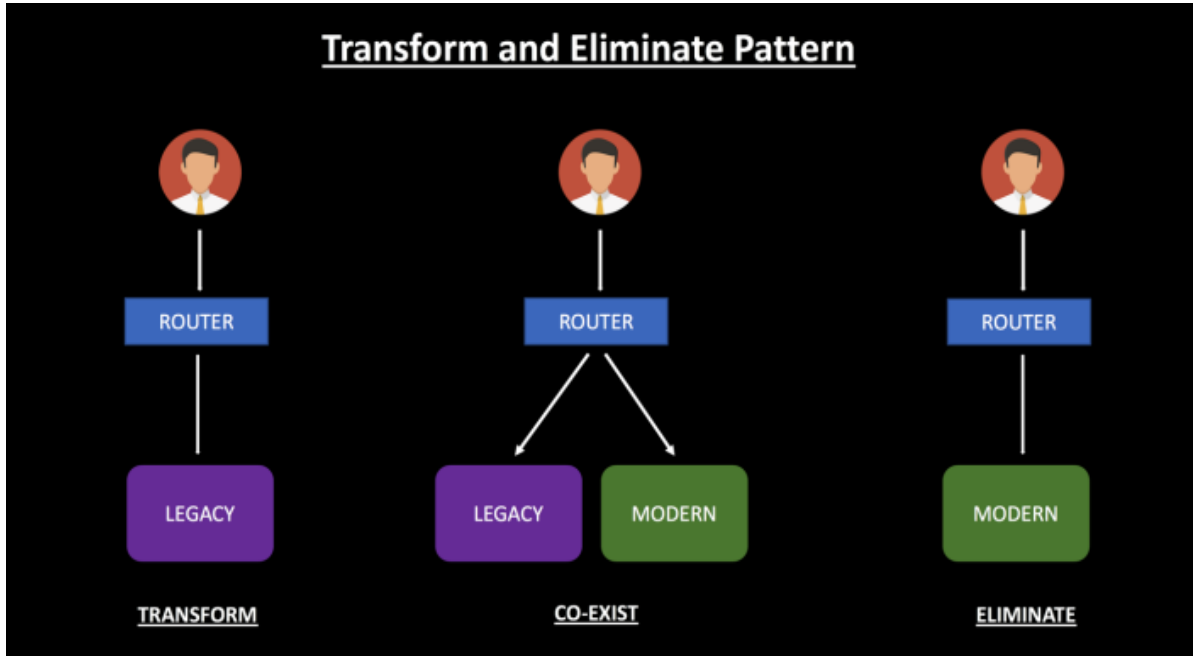
2. Build, transport & eliminate using a router



Transit monolith application to microservices using “Strangler Pattern”

- Rewriting a large monolithic application from scratch is a big effort and has a good amount of risk associated with it.
- The Strangler Pattern reduces the above risk. Instead of rewriting the entire application, you replace the functionality step by step.





Microservices Communication Patterns

Microservices Inter Service Communication Plan

A. Synchronous / HTTP calls

- API gateway to discovery server
- All to discovery server
- All to config server
- API gateway to identity management server

B. Asynchronous / Messaging

Microservice A to B through message queues (RabbitMQ,Kafka,Spring AMQP etc.)

C. Event-Sourcing

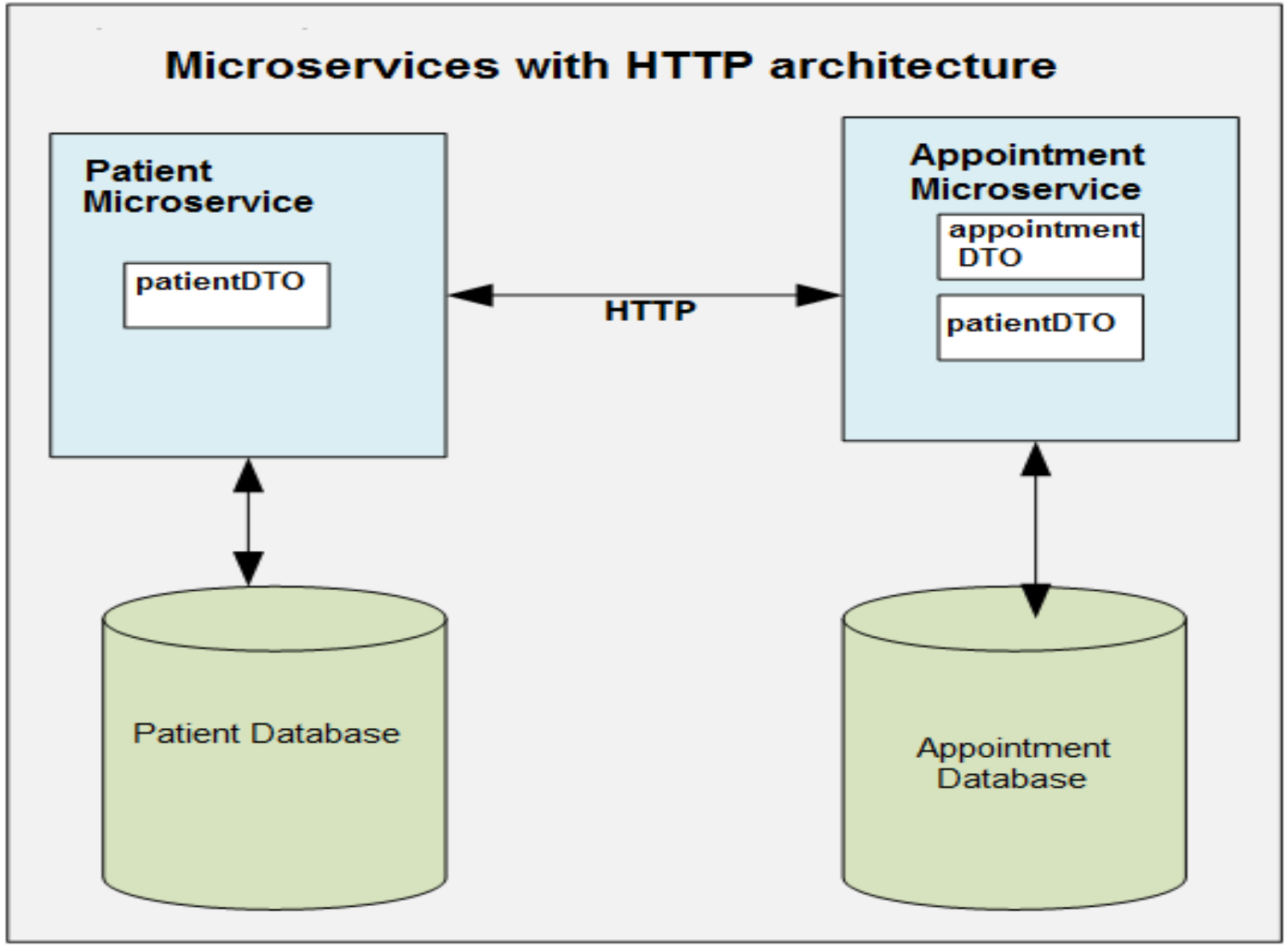
Microservices (e.g. A,B), Event Store, API Gateway, Message Bus

D. Event-Sourcing with CQRS

Microservices (e.g. A,B), Write /Read Event Stores, API Gateway, Message Bus

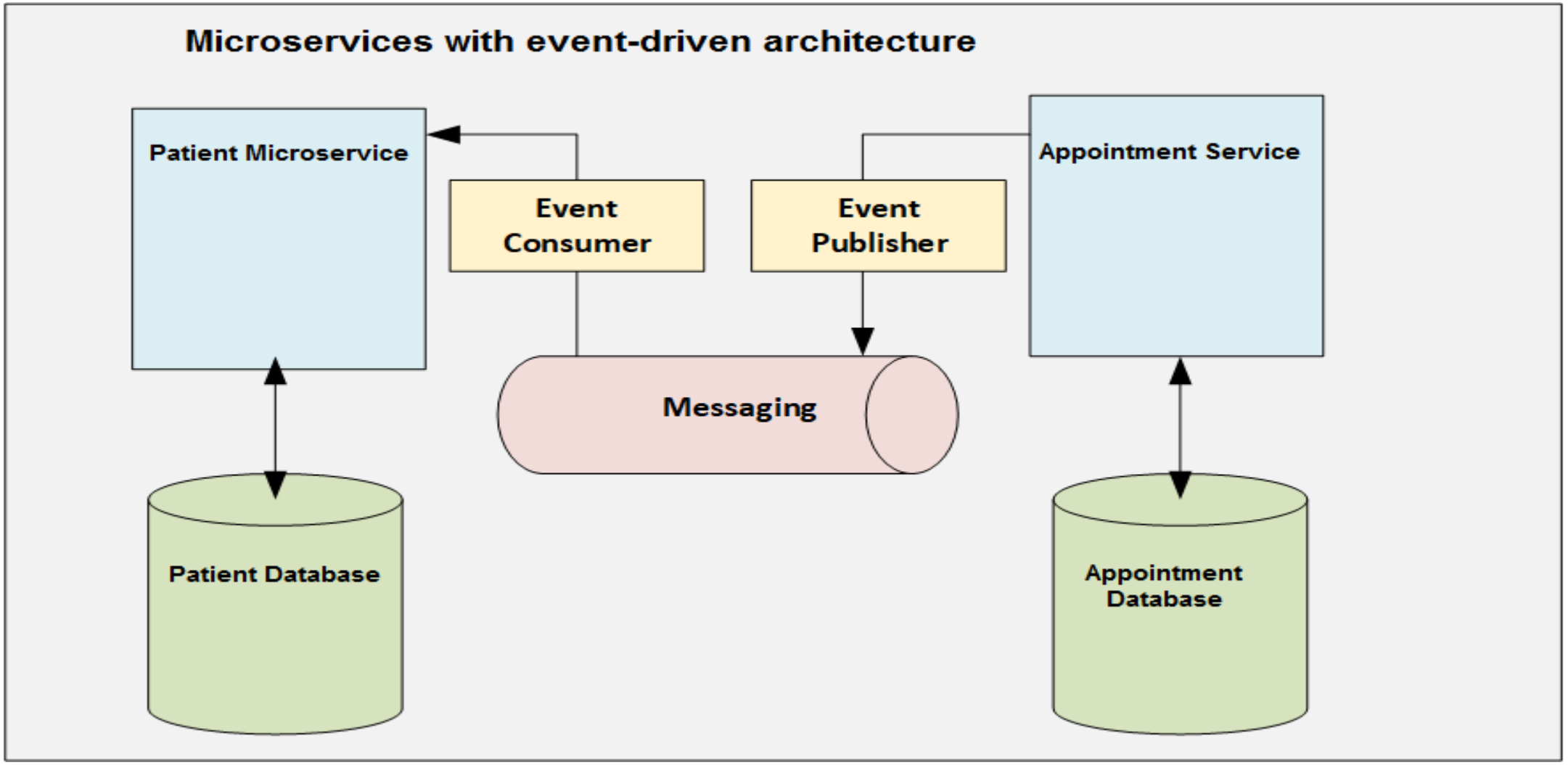
Microservices with Synchronous / HTTP

A

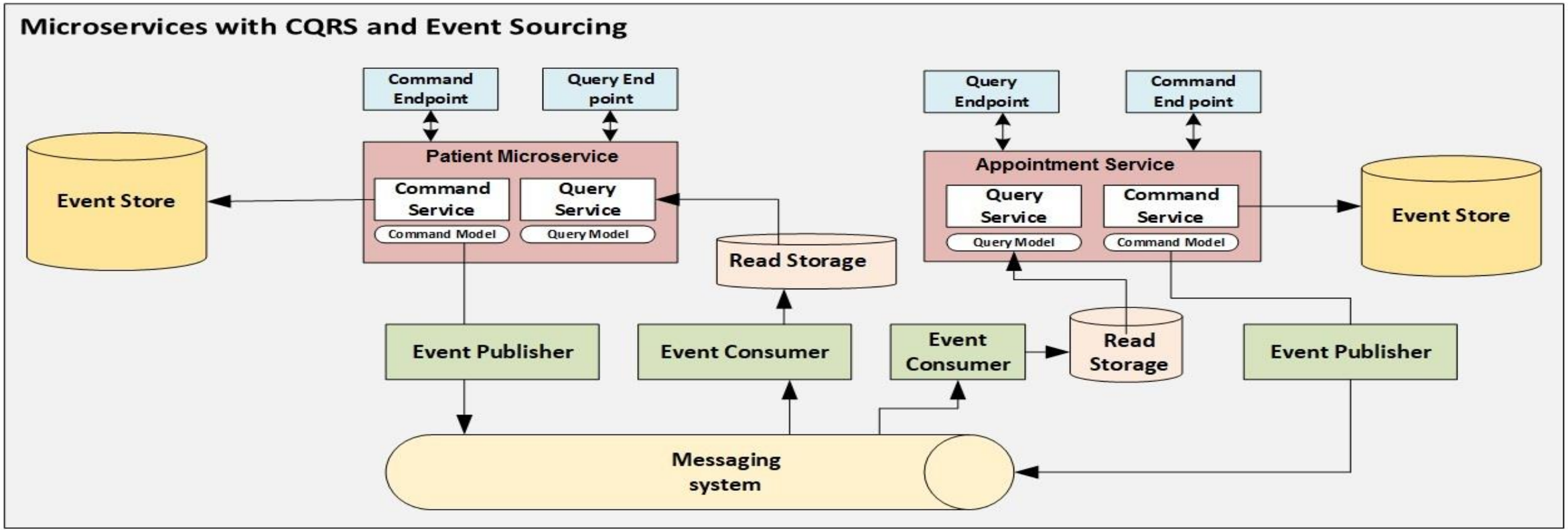


Microservices with Asynchronous / Messaging

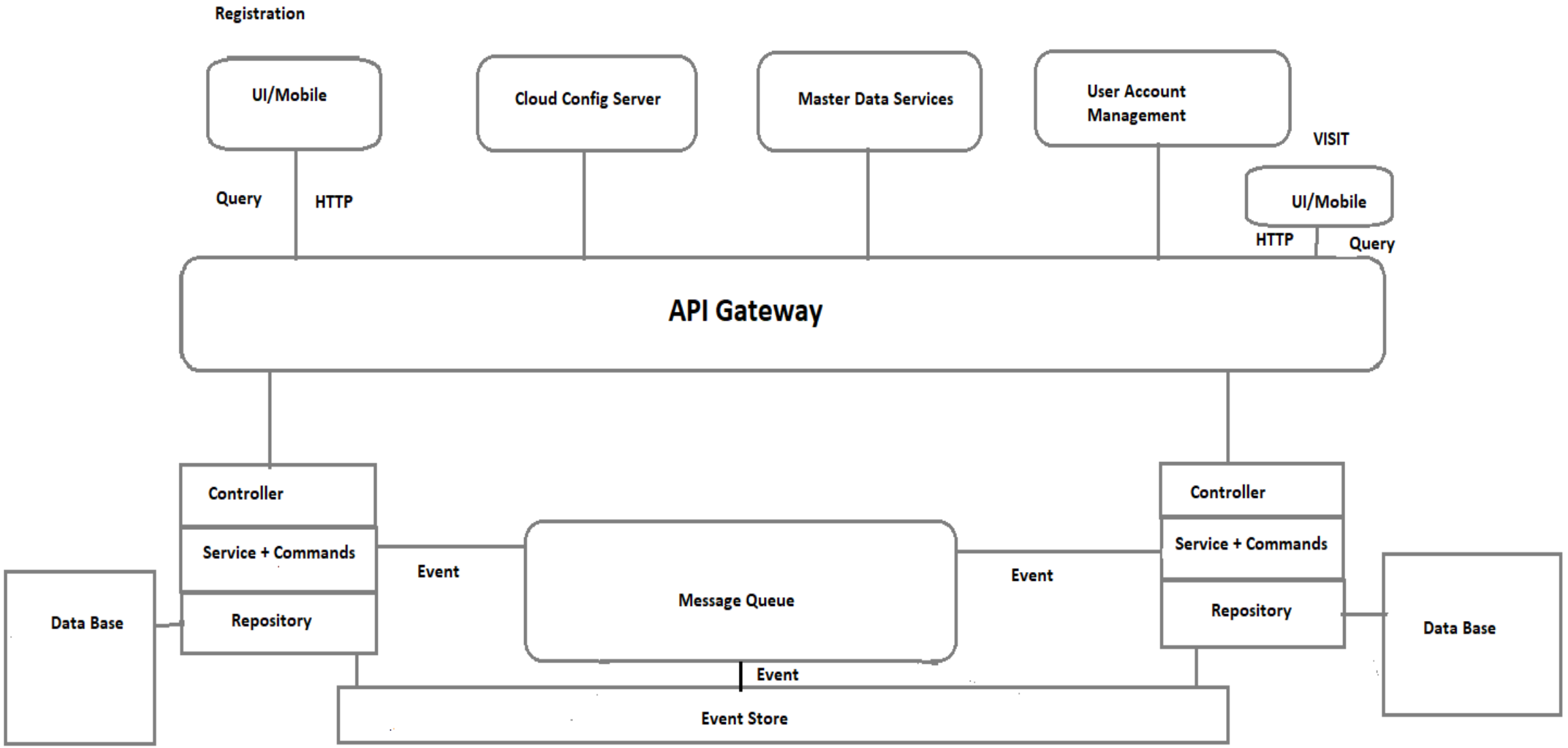
B



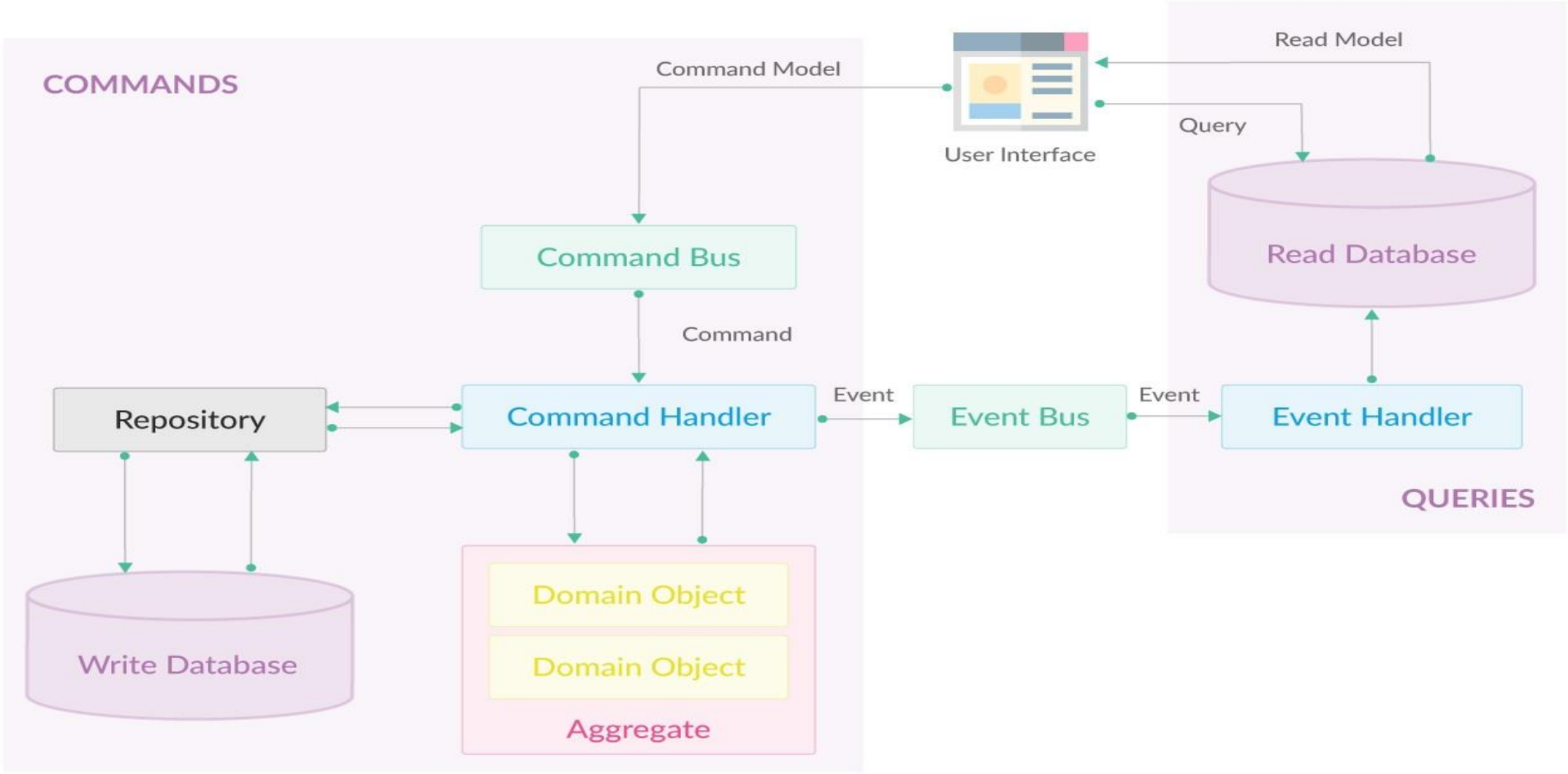
Microservices with CQRS & Event Sourcing



CQRS

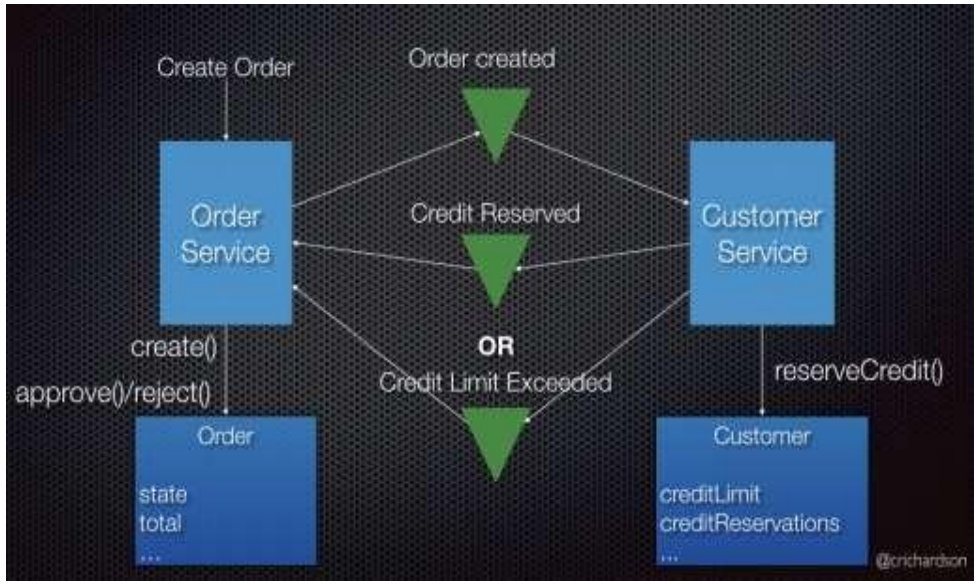

Registration
UI/Mobile
Cloud Config Server
Master Data Services
User Account Management
VISIT
Query
HTTP
UI/Mobile
HTTP
Query
API Gateway
Controller
Service + Commands
Repository
Data Base
Event
Message Queue
Event
Controller
Service + Commands
Repository
Data Base
Event
Event Store

Microservices with Axon Network

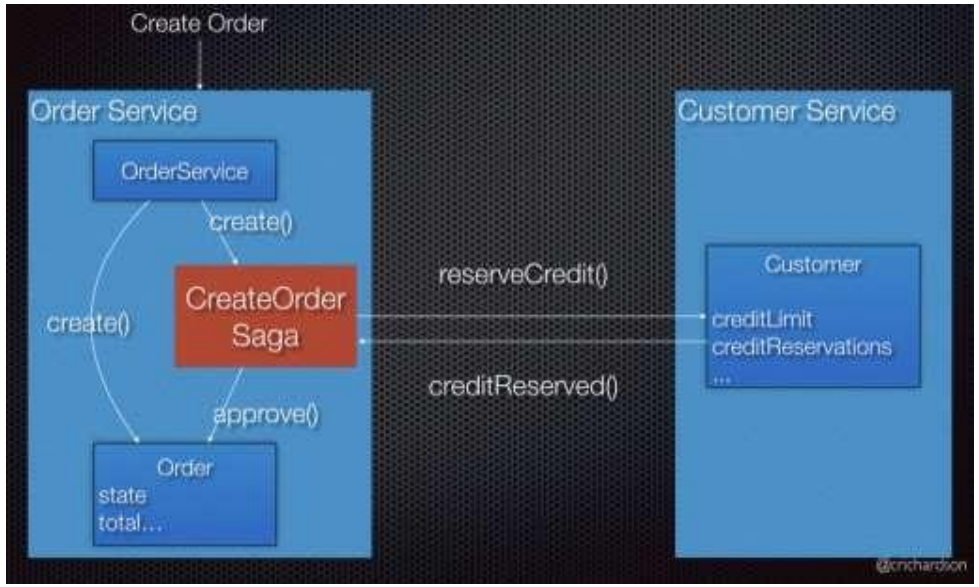


Microservices Coordination – Choreography Vs Orchestration

CHOREOGRAPHY

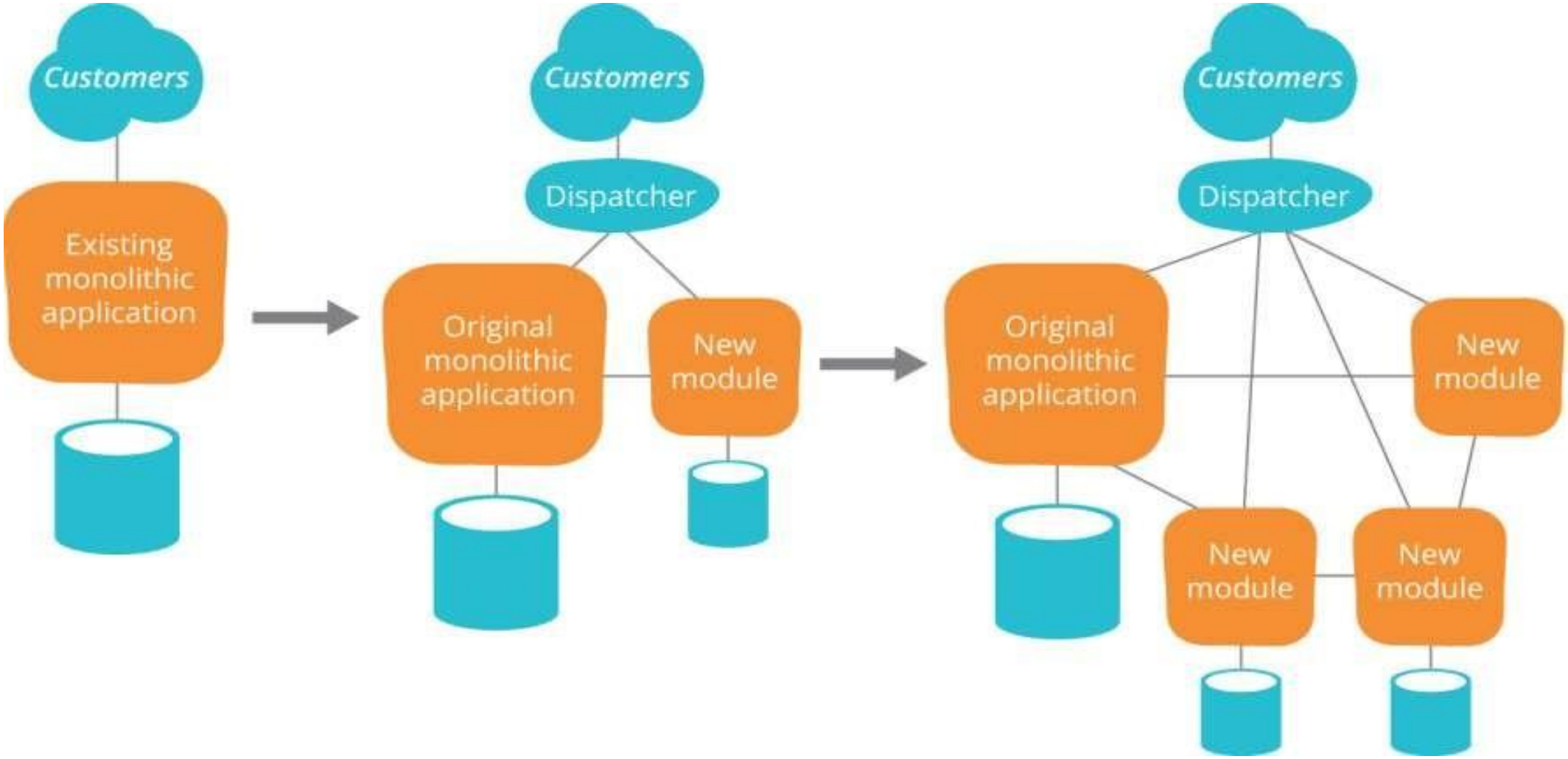


ORCHESTRATION



Monolith to Microservice Architecture (Bolt on approach)

THE STRANGLER PATTERN



Patient Registration Microservice

Business Entities
Person
Patient
Source of Payment
Facility
Care provider

Business Concerns
Walk in Patient Registration

Registration on Patient Portal

Update Registration

Link PHID with Hospital Registration Number

Bulk Registrations

Merge Patient
Insurance Patient Registration

- **User Authentication service**

Responsibility: Authenticates user and assigns system functionality based on Roles and Permissions

Owns: User database

- **Registration service**

Responsibility: Manages Registration
Processes Owns: Patient Database

- **PHID Registry Lookup Service**

Responsibility: Looks up PHID from Person Health registry
Triggers: Patient event store

- **Billing Service**

Responsibility: Manages Insurance Patient Registration
Owns – Billing database, Triggers – Bill Payment event store

- **Update Patient Service**

Responsibility: Updates Patient
Owns – Patient database, Triggers – Patient event store

- **Merge/UnMerge Patient Service**

Responsibility: Merges/Unmerges Patient
Triggers – Patient event store

Microservice CQRS Based Event Sourcing Architecture – Patient Registration

Patient Registration Microservice

Commands

CreatePatientCommand
UpdatePatientCommand
MergePatientCommand
UnMergePatientCommand
LinkPHIDWithFacilityRegistrationCommand

Events

PatientCreatedEvent
PatientUpdatedEvent
PatientMergedEvent
PHIDCreatedEvent
etc.

Queries

getPatientByCareProvider
getPatientBased

Microservice CQRS based Event Sourcing Architecture – Visit Microservice

Visit Microservice

Commands:

CreatePatientEncounterCommand
UpdatePatientEncounterCommand
ActivatePatientEncounterCommand
DeactivatePatientEncounterCommand
PatientEncounterVisitCancellationCommand
CreateEpisodeCommand
ActivateEpisodeCommand
UpdateEpisodeCommand
DeactivateEpisodeCommand

Events

PatientEncounterCreatedEvent
PatientEncounterUpdatedEvent
PatientEncounterActivatedEvent
PatientEncounterDeactivatedCommand
VisitCancellationEvent
EpisodeCreatedEvent
EpisodeUpdatedEvent
EpisodeDeactivatedEvent

Queries

GetPatientEncounterByuniqueHealthIdentificationNumber
getAllPatientActiveEncounters
getAllPatientDeactivatedEncounters
getPatientEpisodeByuniqueHealthIdentificationNumber
getAllPatientActiveEpisodes
getAllPatientDeactivatedEpisodes
getPatientCohortGroupsByDiseaseCode

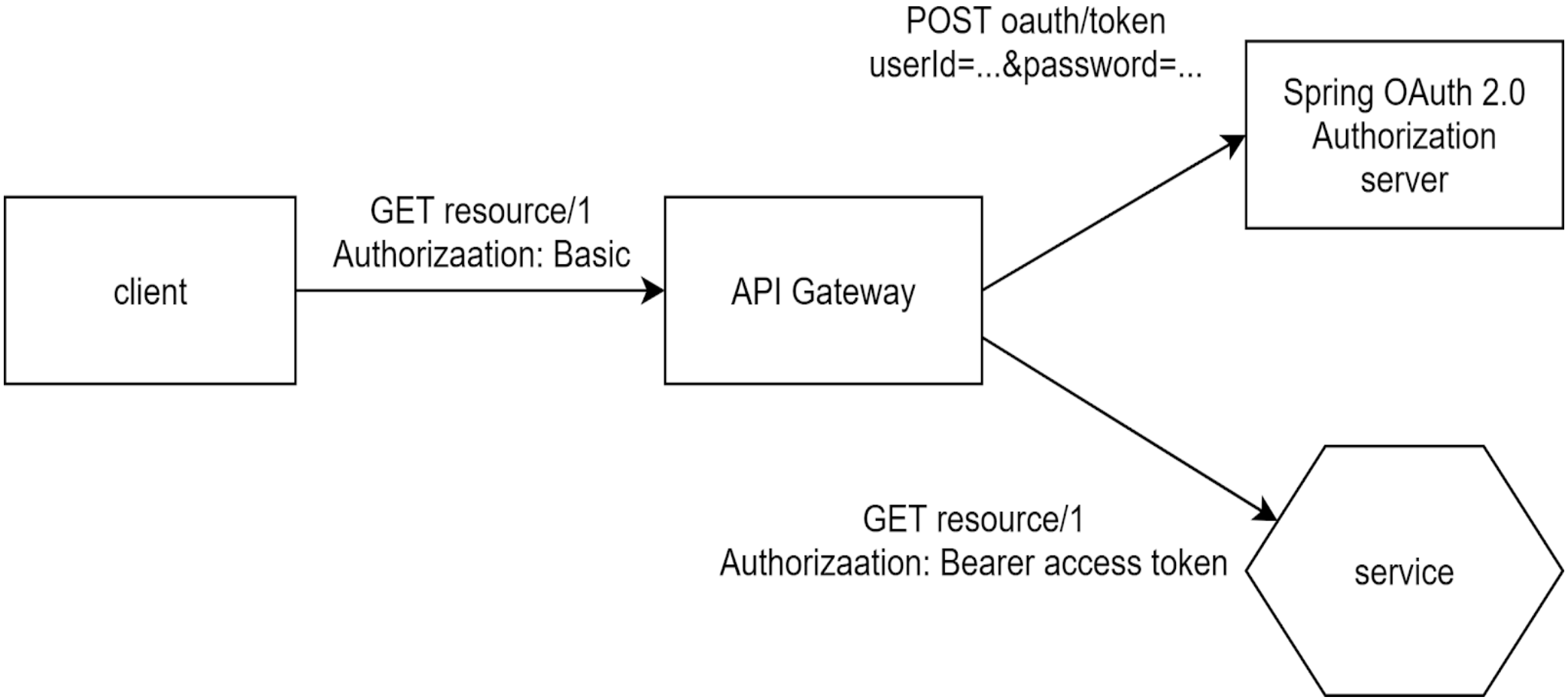
Microservices Architecture Ecosystem

- *Business Microservices*
- *API Gateway*
- *Discovery Server*
- *Configuration Server*
- *Identity Management Server*
- *Authentication Server*
- *Logs Aggregator Server*
- *Logs Analyzer*
- *Admin Server*
- *Databases*
- *Message Queues*
- *Load Balancers*
- *Reverse Proxies*

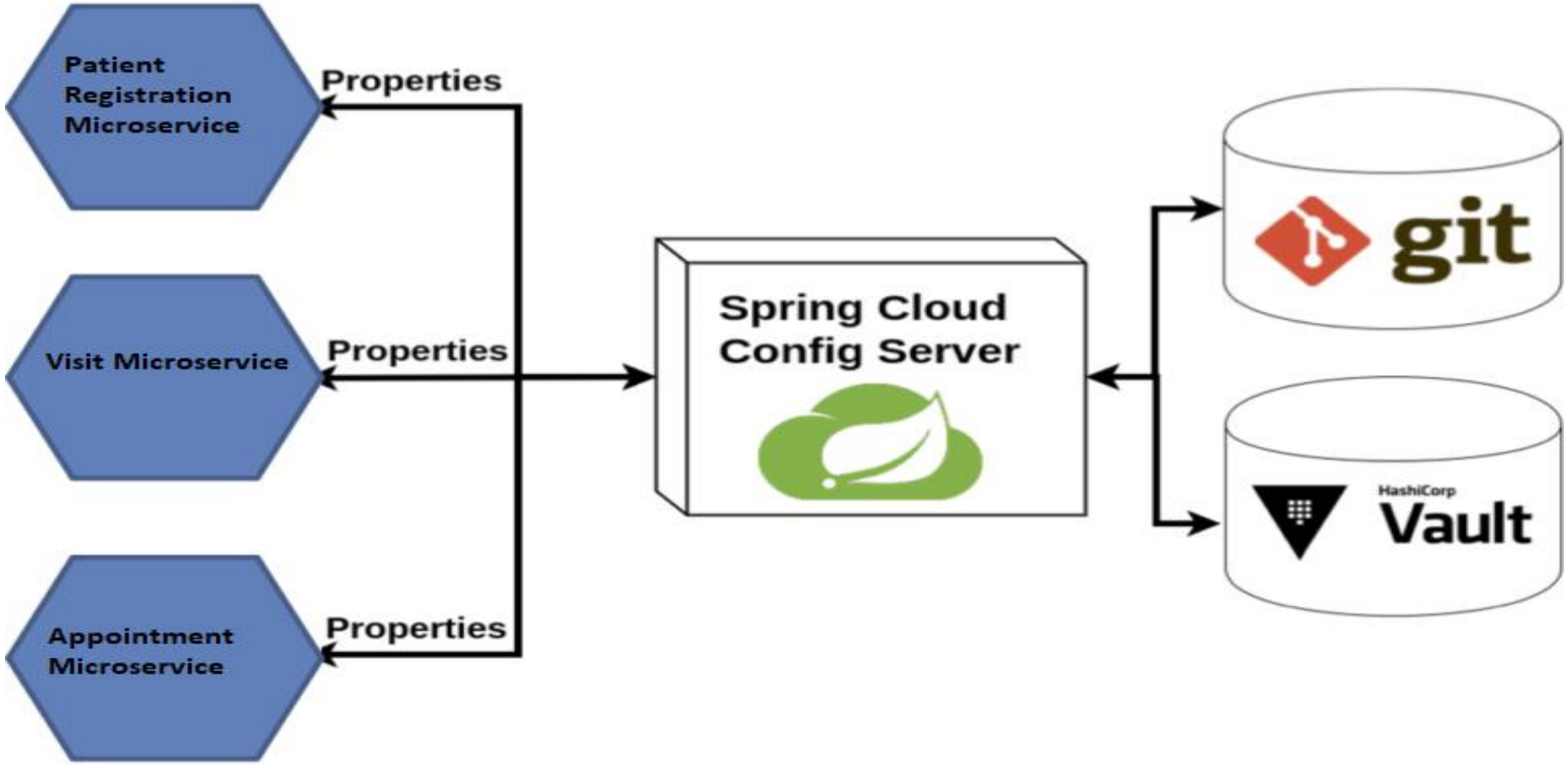
Microservices Architecture – Technology Framework

Technologies, frameworks ...			
Netflix Ribbon	Used to implement client side load balancing.	**Spring cloud config service**	Used to provide centralized configuration for all microservices
ELK	Used to provide centralized logging in microservices architecture	**Zuul Gateway**	Used to provide public API routing
Sleuth	Used to provide corelation id between inter-microservice comunication	Sidecar Proxy	Infrastructure components
Consul	Discovery service from Hashicorp with Spring Cloud support.	Docker	Container Management
Hystrix	Communication resilience wrapper from Netflix provides impl. for circuit breaker, timeout, bulkheads, fallback, etc.	Kubernetes	Container Cluster Management
Resilience4J	Communication resilience wrapper library that provides impl for various resilient patterns including circuit breaker, bulkheads, etc.	Axon Framework	CQRS Event Sourcing Framework
OpenFeign	A HTTP client from Netflix that provides client side load balancing, and can work with Hystrix.	Apache Kafka	Message Broker
Apache HTTPClient	A HTTP client from Netflix that provides support for basic resilience patterns like timeouts, retrys, etc.		

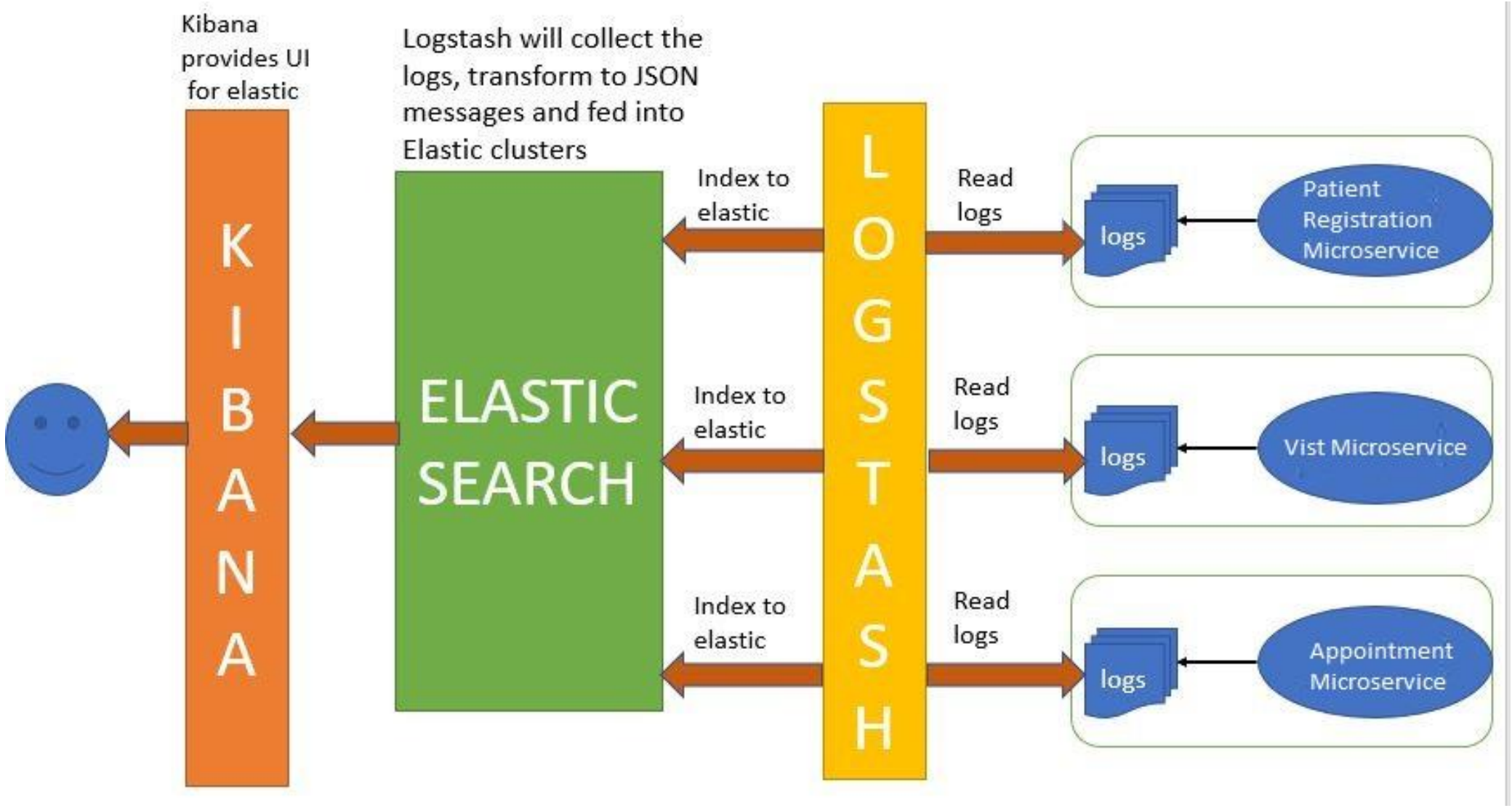
APIGateway (Edge Server)



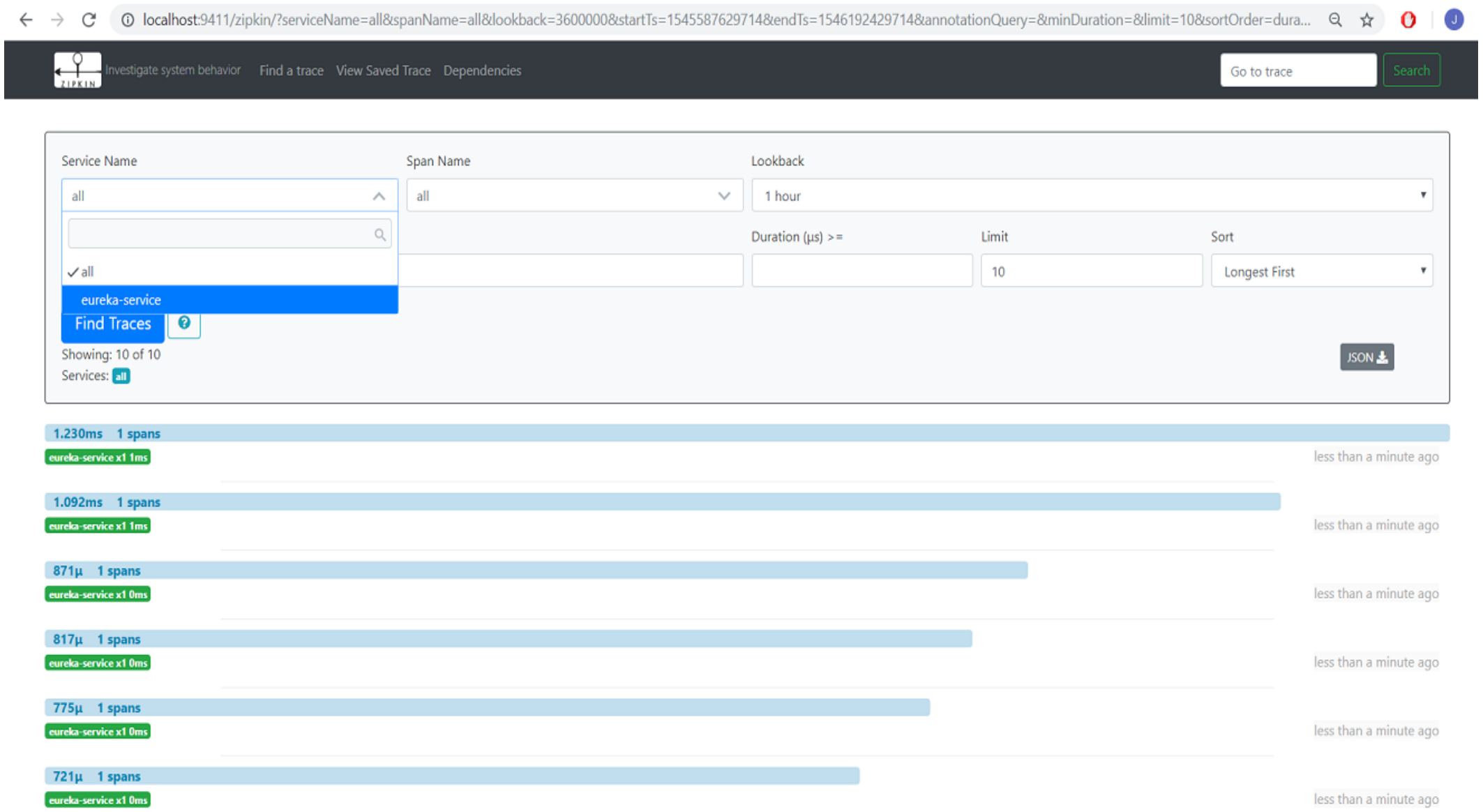
Cloud Config Server for Externalizing the boot configurations



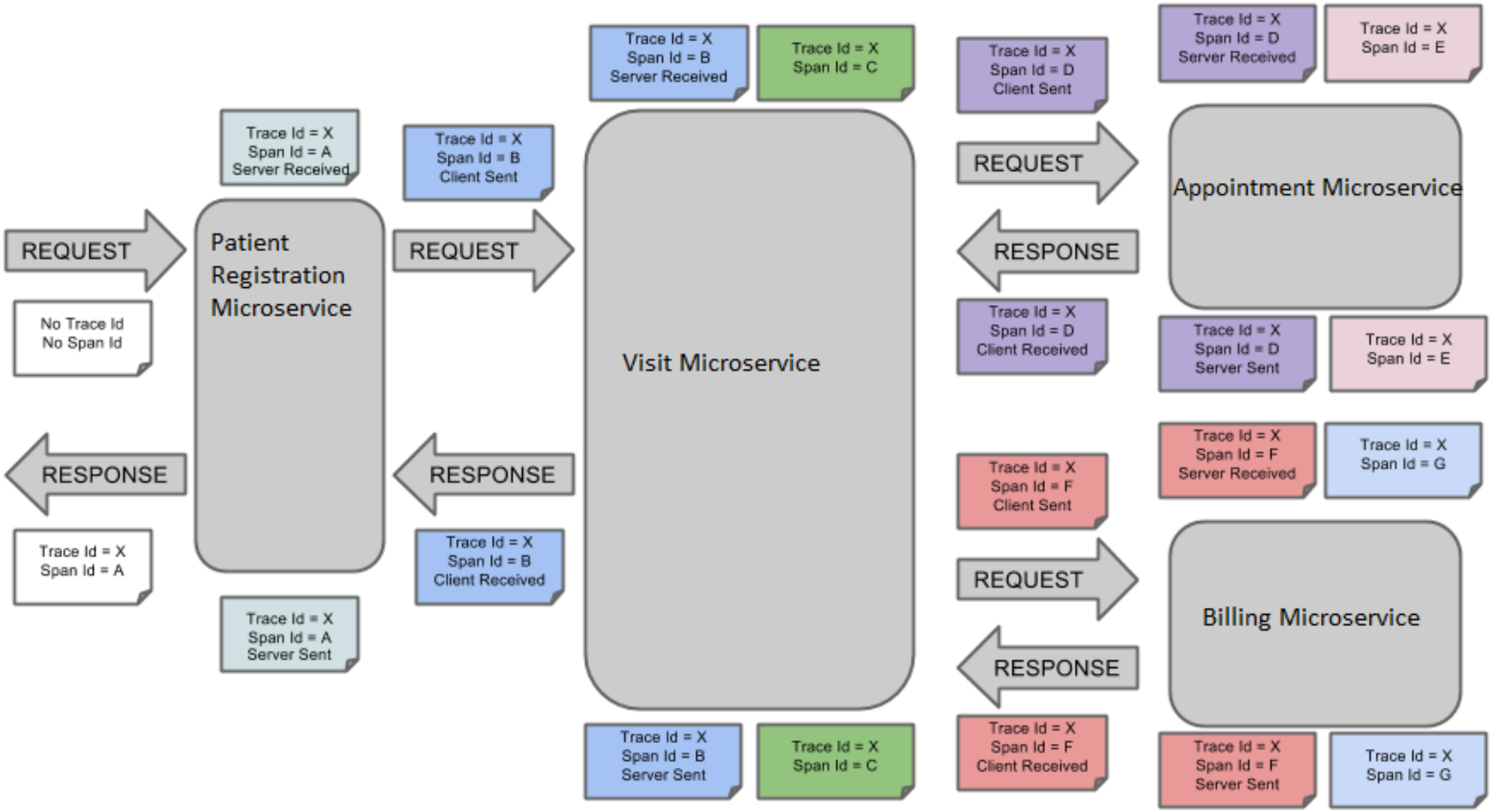
ELK for Distributed Log Management



Zipkin (TraceID Admin Panel)



Sleuth Trace And Span Id Management



THANKS!

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NDHB & Digital Health Regulatory Updates (Detailed)

- ✓ MAY 17 2020 - NATIONAL DIGITAL HEALTH MISSION TO be LAUNCHED - https://ehealth.eletsonline.com/2020/05/national-digital-health-mission-to-be-launched-major-announcements-by-sitharaman/?fbclid=IwAR0WBxJz-xNUDO0E7gjhkOYw_zQzVjaBEe1Dl2kEv8g09UkHvzYoOnqM4X8
- ✓ The Ministry of Health & Family Welfare released the report on National Digital Health Blueprint (NDHB) on 15th July 2019- https://www.jagranjosh.com/current-affairs/national-digital-health-blueprint-released-by-health-minister-harsh-vardhan-1563269295-1
- ✓ Personal Data Protection Bill draft was submitted by Srikrishna Committee in 2018. The **Bill** was approved by the cabinet ministry of India on 4 December **2019** as the **Personal Data Protection Bill 2019** and tabled in the Lok Sabha on 11 December **2019 and is under review by the Standing Committee.** http://164.100.47.4/BillsTexts/LSBillTexts/Asintroduced/373_2019_LS_Eng.pdf
- ✓ Medical Devices- A Perspective & The Medical Devices (Amendment) Rules, 2020- Before any rules were notified for medical devices, they were being governed solely by the dated and redundant Drugs and Cosmetics Act, 1940 with no specific provisions or aspects pertaining to the regulation of medical devices in India.
- ✓ 25th March 2020- Telemedicine guidelines https://www.mohfw.gov.in/pdf/Telemedicine.pdf
- ✓ Electronic consent framework-technical specifications http://dla.gov.in/sites/default/files/pdf/MeitY-Consent-Tech-Framework%20v1.1.pdf
- ✓ Aarogya setu data processing protocols and punishment on violation of guidelines (data sharing) Aarogya-setu-data-access-and-knowledge-sharing-protocol-2020
- ✓ Health database- https://www.livemint.com/science/health/covid-19-india-to-maintain-interoperable-health-registry-of-citizens-11590934227117.html
- ✓ Medical insurance for workers made mandatory- https://www.timesnownews.com/business-economy/personal-finance/insurance/article/post-lockdown-medical-insurance-for-workers-made-mandatory/583022?fbclid=IwAR2_uunMvZ4NCdsIRMjkbnwk7r472IipW_cCkJGOz7_NGanBWQuV8jJo0l4
- ✓ Clinical Establishment Amendment Rules 2020 http://clinicalestablishments.gov.in/En/1062-notifications.aspx
- ✓ COVID19 updates in standards (NRCES) https://www.nrces.in/news
- ✓ Arogya Setu, open source code https://pib.gov.in/PressReleasePage.aspx?PRID=1626979
- ✓ Standing Finance Committee approves NDHM - https://ehealth.eletsonline.com/2020/06/govt-set-to-implement-national-digital-health-blueprint-standing-committee-okays-proposal/?fbclid=IwAR17sIGFZQwyI94Er9GjoEvFIZlEbsJHYSGPsQ6SLu91mPXb84_r5yU9j3E
- ✓ COVID Bio Repositories (ICMR) https://www.icmr.gov.in/cbiorn.html

Digital Health | Access Health Digital's Contribution

- eObjects were first written by Prof Dennis Streveler and Dr Pankaj Gupta in a white paper in ***Nov 2018 that was published by Niti Aayog in the book Health Systems for New India, Chapter 5 - Reimagining India's Digital Health Landscape Wiring the Indian Health Sector in Nov 2019.***

- The ***eObjects*** have now been ***adopted by Joint working Group of National Health Authority NHA and Insurance Regulatory Development Authority IRDAI Subgroup on common IT infrastructure***, in its report published on 11 Sep 2019 and will be built into the India's national Health Claims platform.

- ***Vision Document on Data & Insights Hub at AB-PMJAY*** was articulated and published for National Health authority.

- ***AHD - NHA partnership for folding AHD's SEA program into NHA's Health Innovation Program***. This will enable all current SEA members to be immediately supported in their efforts by the Government of India - through NHA's Market Access Program.

- ***National Registries Concept Note-*** Published Concept Notes on various NDHB recommended National Registries- Facility Registry, Health worker Registry, Drug Index and Doctor's registry in open source to provide techno-functional roadmap to develop these registries in India.

- ***OpenBodhik.in-*** Open Body of Digital Health Insights and Knowledge, is an Opensource digital health community run by ACCESS Health Digital [AHD]. ***Open source community created*** to foster a culture of contribution, collaboration and innovation in digital healthcare - as a key component of nation building. The objective is to move India towards digital health democracy, freedom and global leadership. Initial NDHB standards and building block based digital health assets, have been made available to all through volunteer and SEA member contributions.