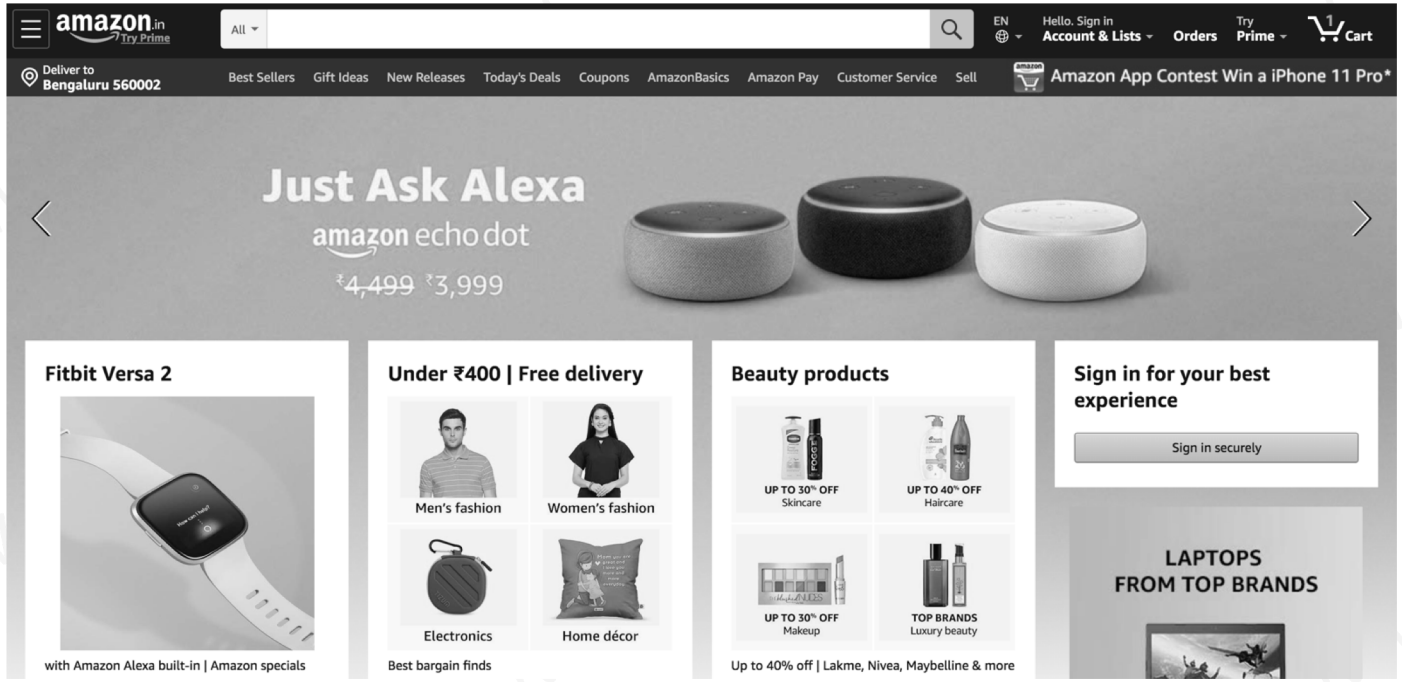
Developer To Architect

Designing System Architecture

Case Study – eCommerce System

Problem Statement

- Architect a highly scalable and reliable online e-commerce system
  - It should be similar to Flipkart or Amazon in scale



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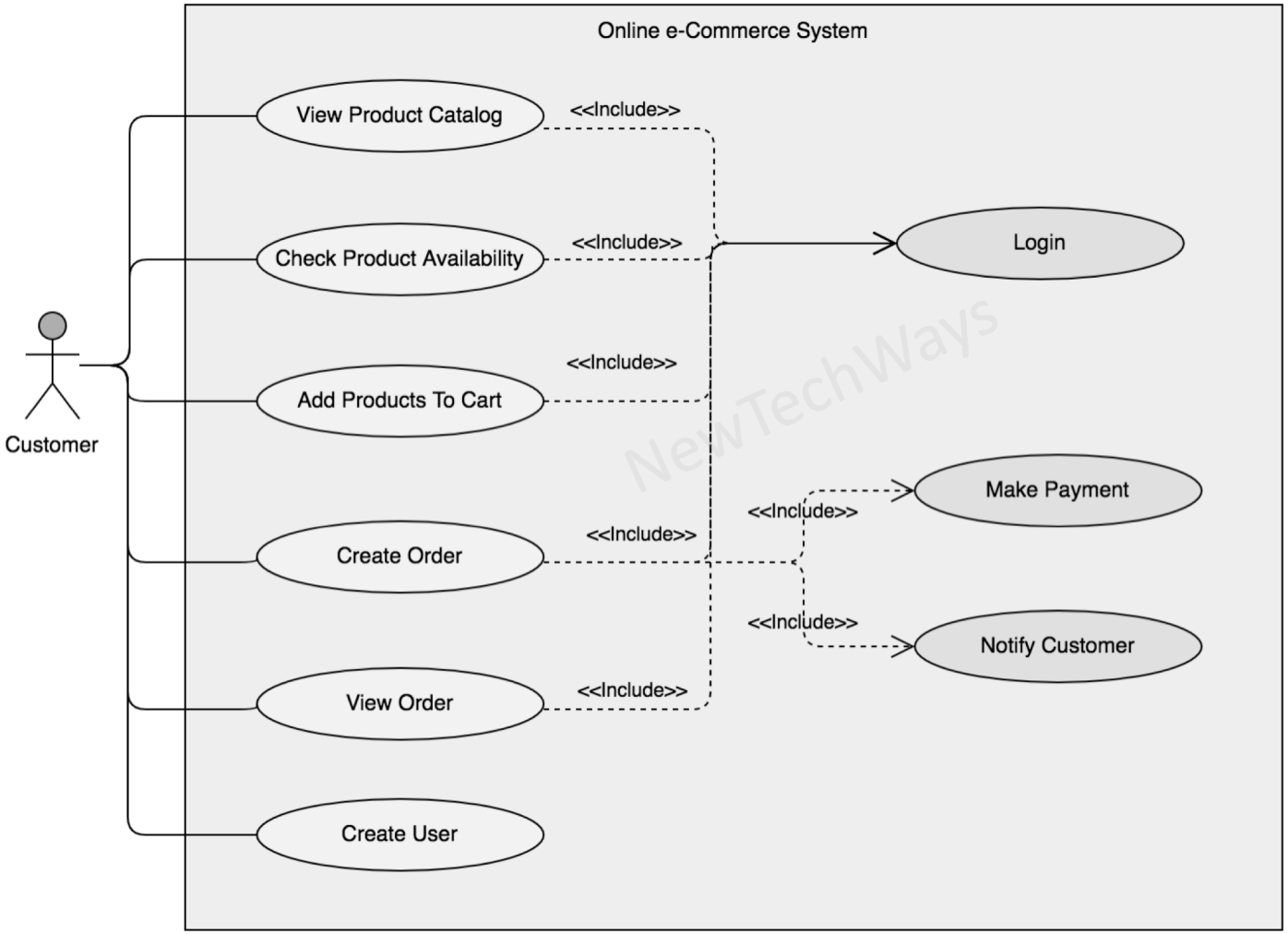
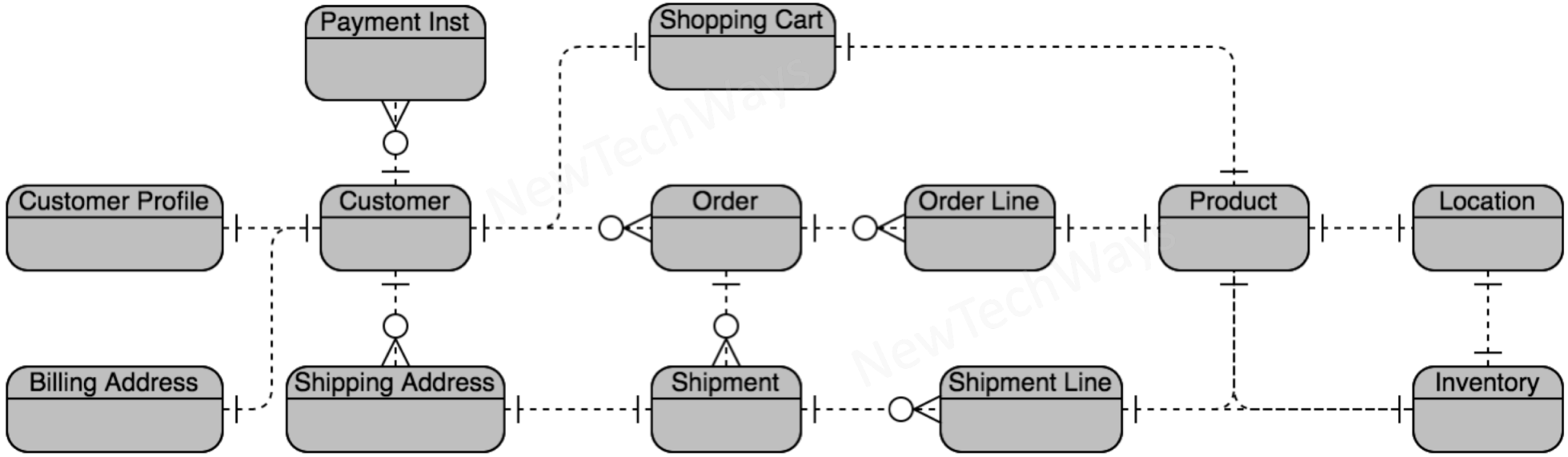
Application Architecture

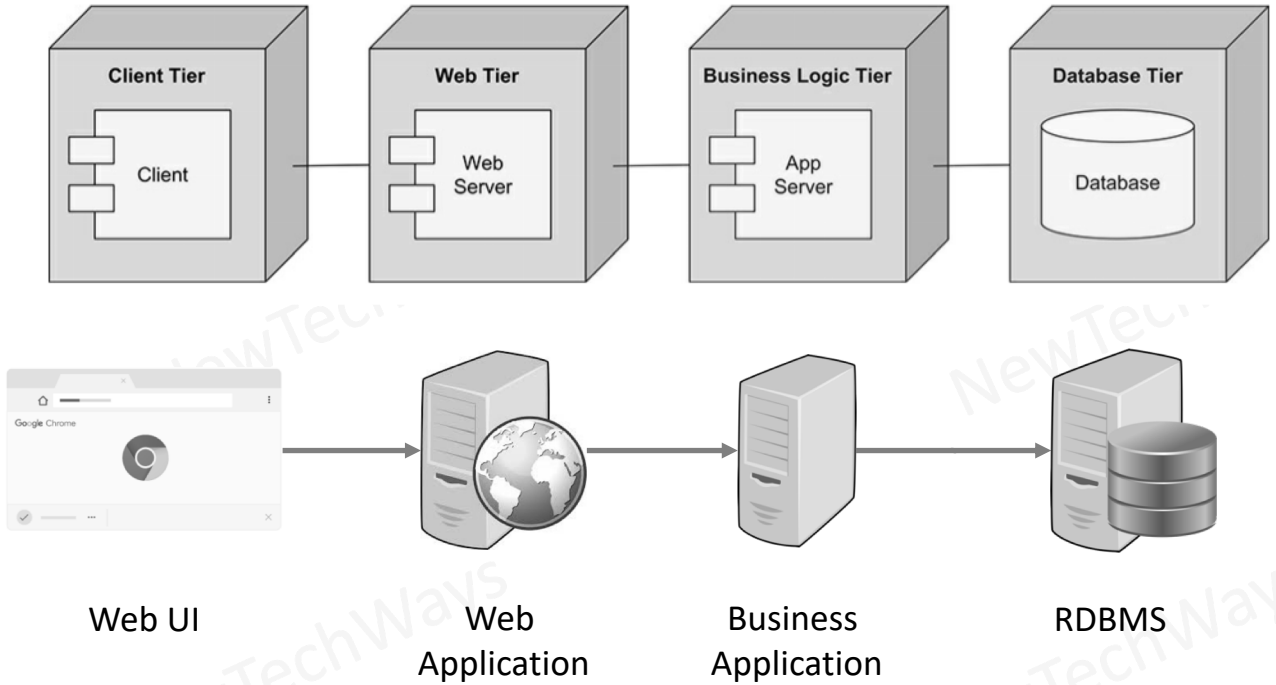
Use Case Model

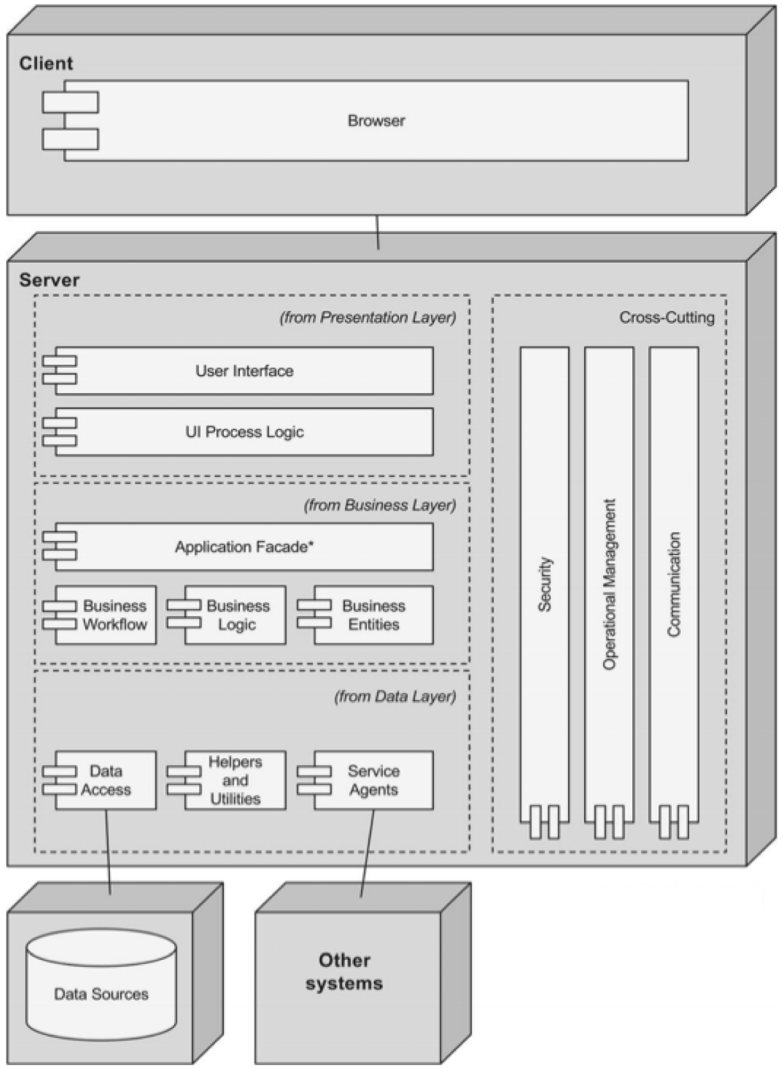


Domain Model

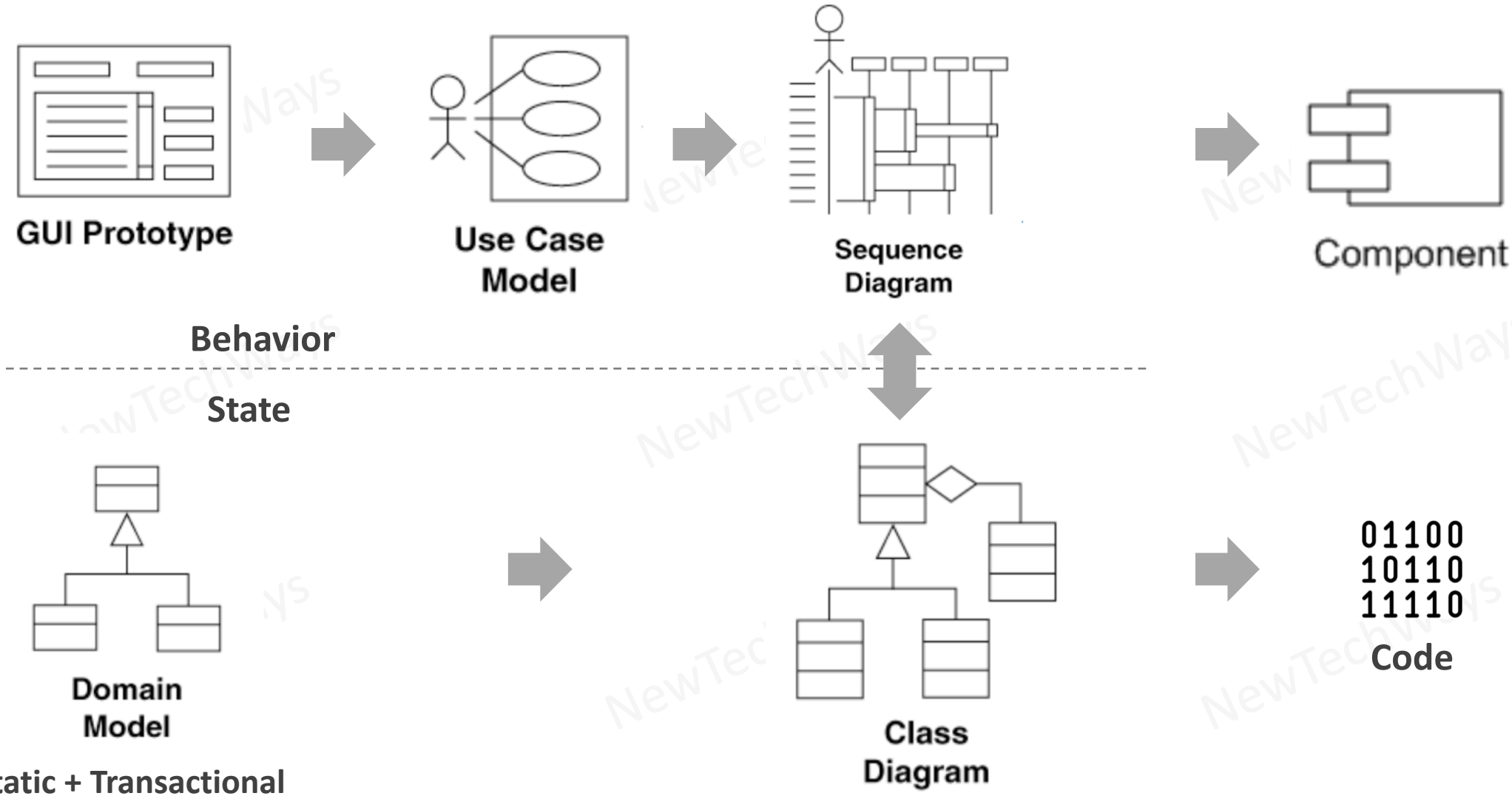


Component Model





Low Level Design



What About?

High Availability

Response Latency

Global Customers

System & Data Security

File storage for Catalog Images

Mobile Support

Unstructured Data Storage & Analytics

Cloud Deployment

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Going Beyond

Application Architecture To System Architecture

Application Architecture Vs System Architecture

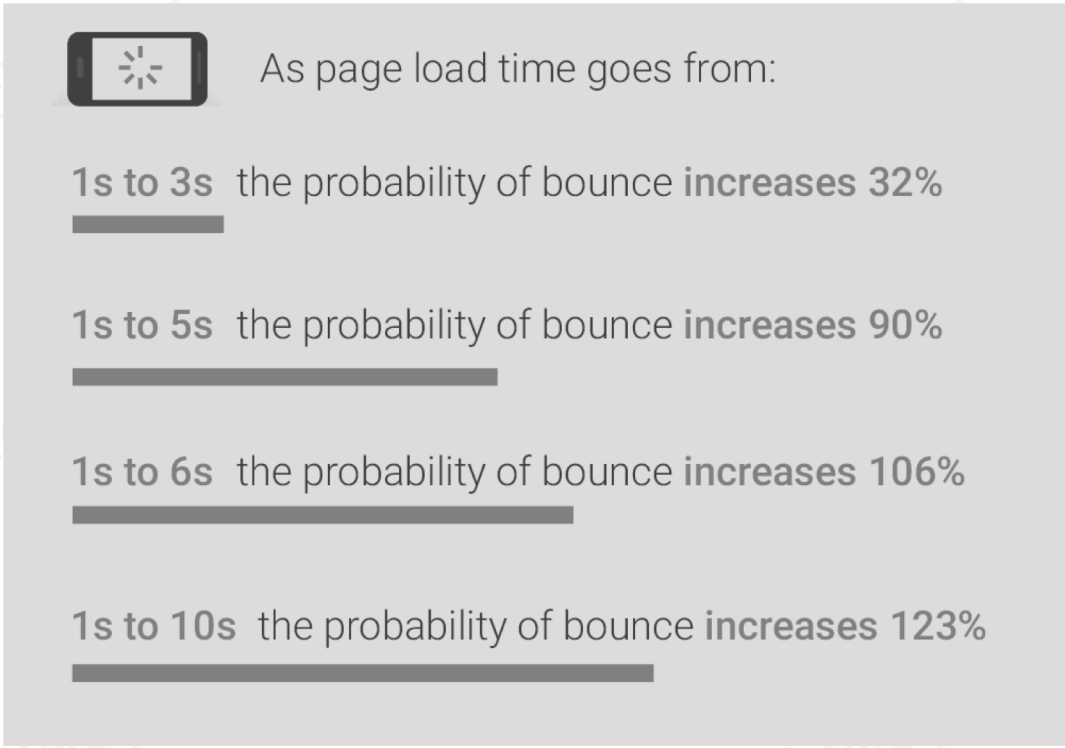
System level challenges
surface up in large scale systems

Scale, Reliability, Security, Deployment are
biggest concerns for a large scale system

Latency Requirements

- UI page load in < 250ms
  - across the globe
- Customer transactions < 3 sec

- Latency is not an option
  - 10 years ago, Amazon found that every 100ms of latency cost them 1% in sales
  - Now Akamai study shows that every 100-millisecond delay in website load time can hurt sales by 6%
  - Google found an extra .5 seconds in search page generation time dropped traffic by 20%
  - A stock broker can loose millions if their trading platform is 5ms behind its competition



Scalability Requirements

- 10 million requests/day
- 1K to 100K simultaneous users
- Global customer base
- 100 million products
- Transaction data for last 5 years
- Petabytes of log data

- For 10 M requests with average response size of 10KB
  - Data Outflow = 10M x 10KB = 100 GB
- For 100 M orders/year with average order size of 10 KB, five years data
  - Data storage = 5 x 100M x 10KB = 5 TB
- For 100 M products with average product description/image size of 1 MB
  - Data Storage = 100M x 1MB = 100 TB
- Logs generated and archived
  - Data Storage => in Petabytes
- Buying customers in 100 countries

Availability & Reliability Requirements

- Unavailability results in
  - Business loss
  - Reputation loss
- 99.95% Availability
  - Maximum cumulative disruption of 4 hours 22 minutes in an year
- 99.999999999% Durability for storage systems
  - Data once stored is practically never lost
- Disaster Recovery
  - Operations to continue even if a region goes down due to a natural calamity

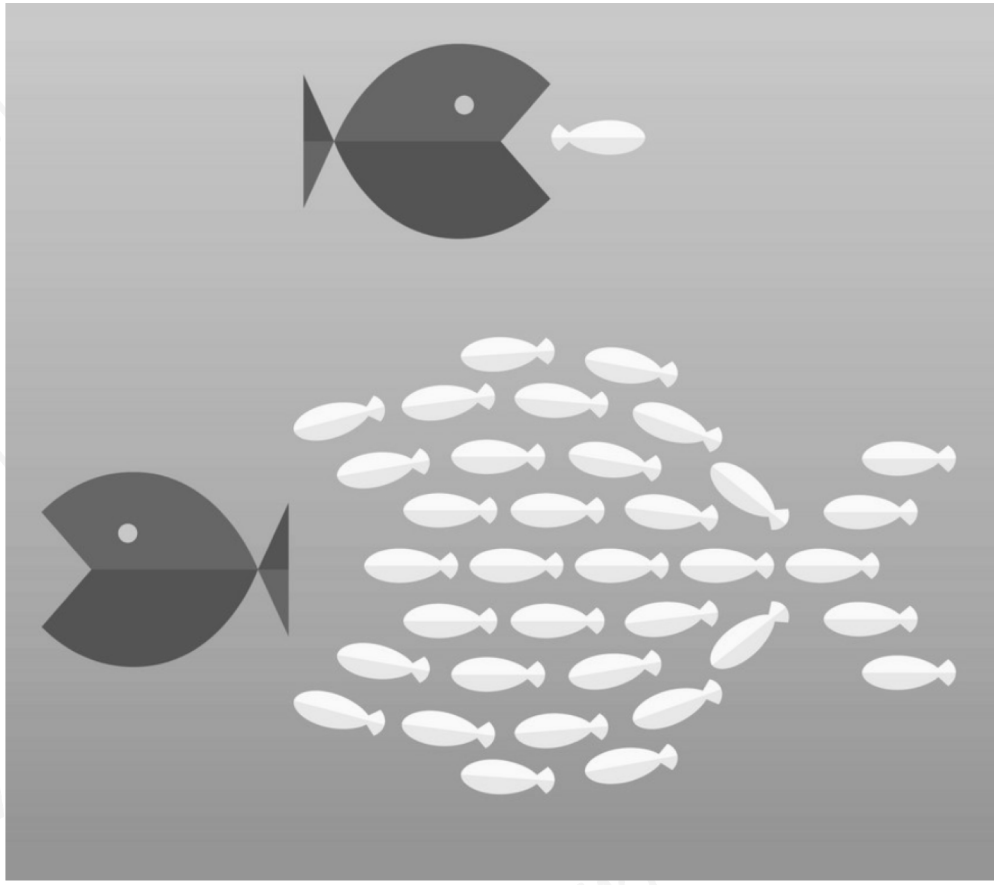
Security Requirements

- Infrastructure protection
  - Network access
  - System access
  - Service access
- Data Protection
  - Data sensitivity classification
  - Protect data at rest
  - Protect data on wire
  - Data backup & replication
- Identity & Access Management
  - Authentication, Authorization
  - Role based access

Designing System Architecture

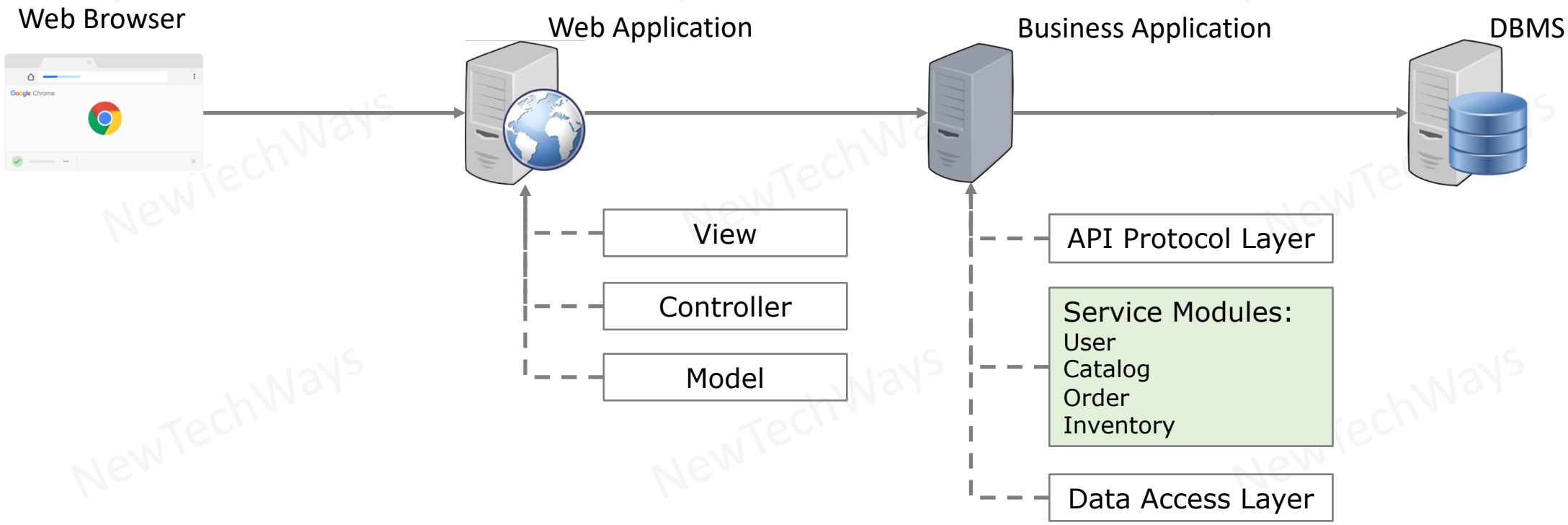
Scalability Principle

- Monolith is an anti-pattern for Scalability
- Scalability goes up with
  - Decentralization
    - More specialized workers – Services
    - More workers – Instances, Processors, Threads
  - Independence
    - Multiple workers are as good as a single worker if they can't work independently
    - They must work concurrently to maximum extent
    - Independence is impeded by
      - Shared resources
      - Shared mutable data



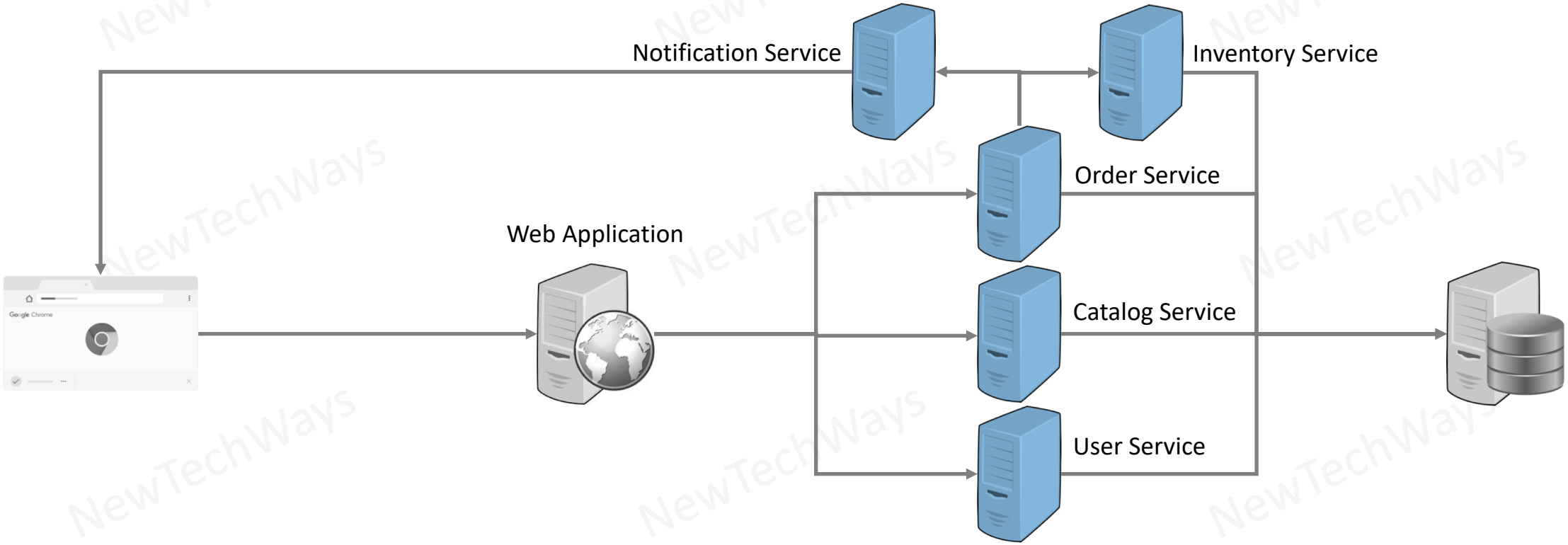
Modularity

- Scalable architecture starts with modularity
  - Provides the foundation for breaking a system function/service into more specialized functions/services



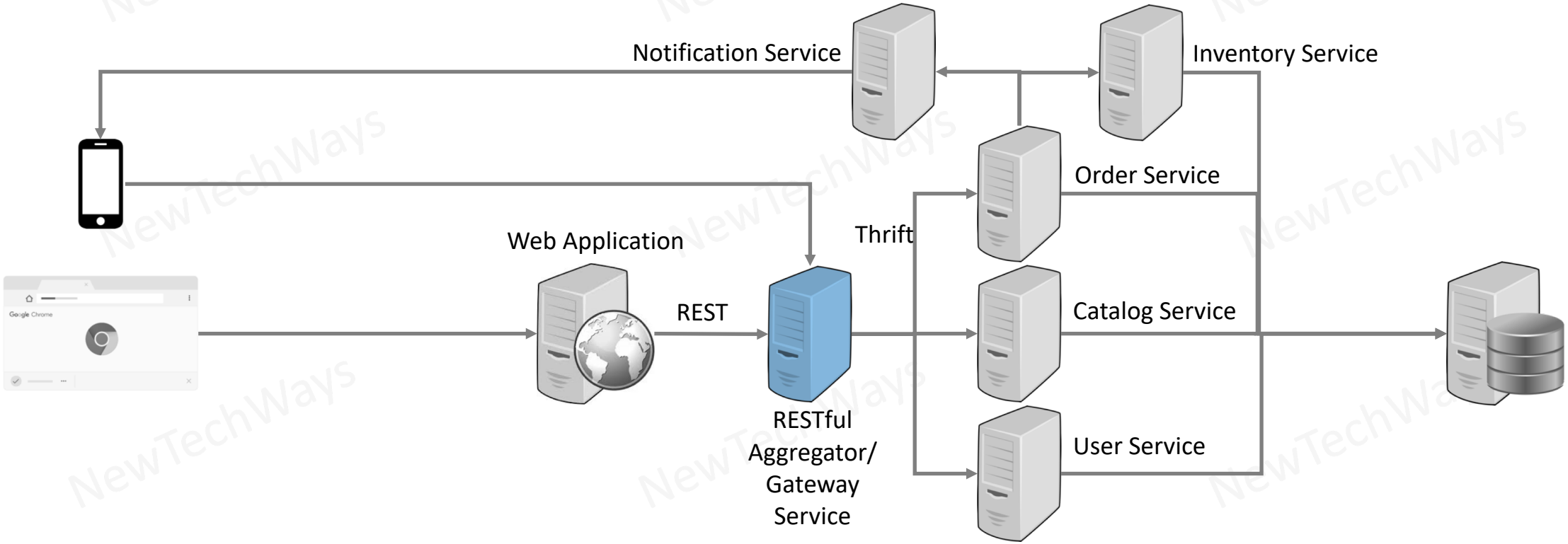
Specialized Services – WebServices

- Services can be scaled differently e.g. Number of instances
  - Cannot be deployed independently due to dependencies



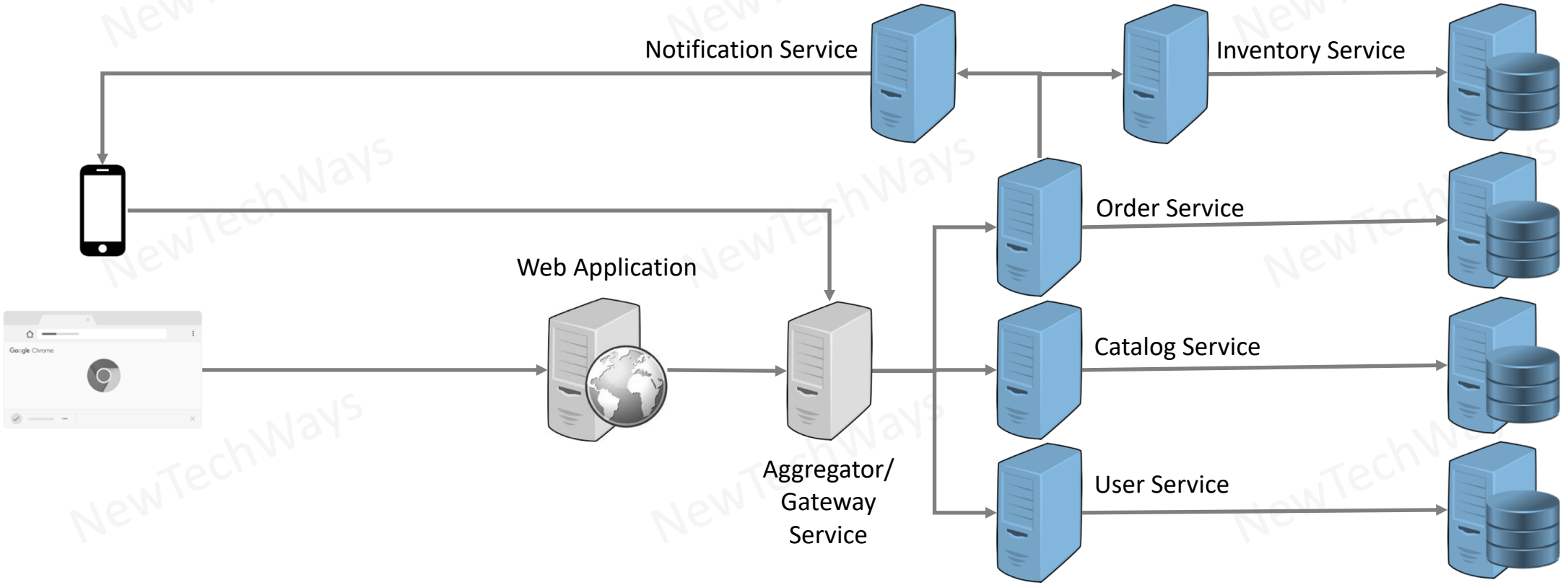
Aggregator Service & RESTful API – Mobile Support

- REST interface for interoperability
  - Takes care of Mobile Support from backend
- RPC can be used internally for performance



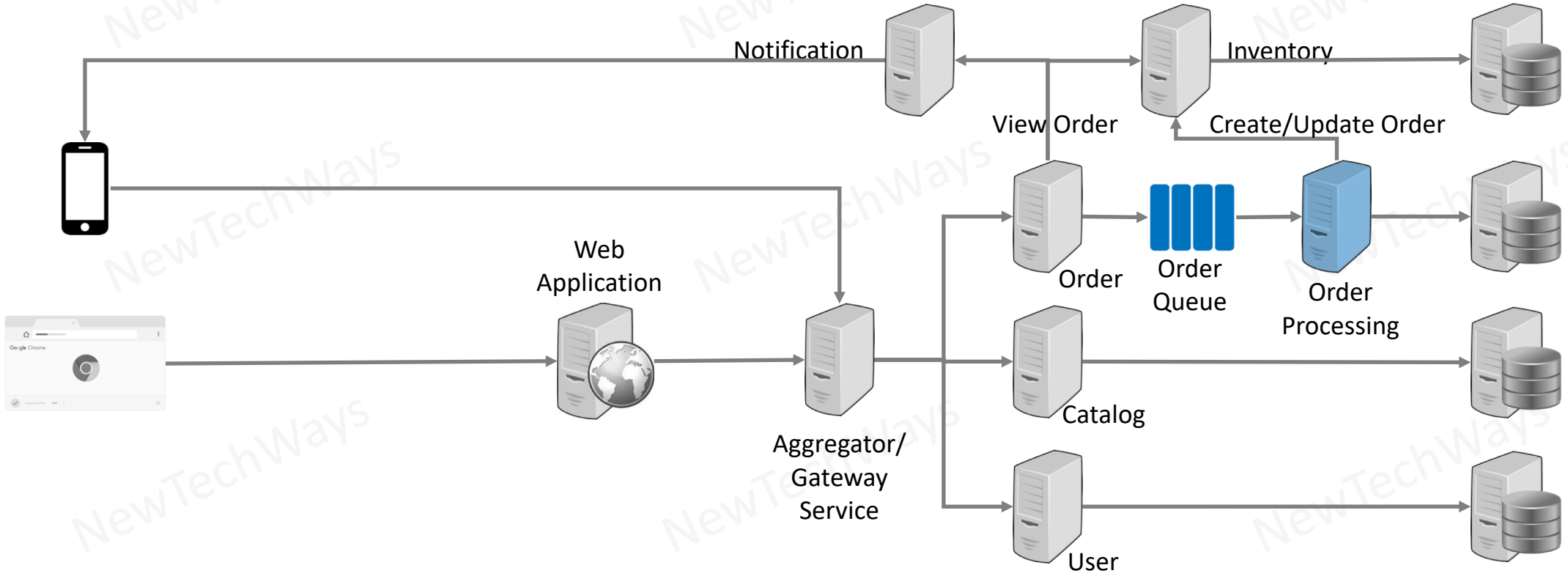
Independent Services – MicroServices

- Micro-Services can be scaled differently and deployed independently
  - Can no longer do inter service ACID transactions and need to deal with eventual consistency



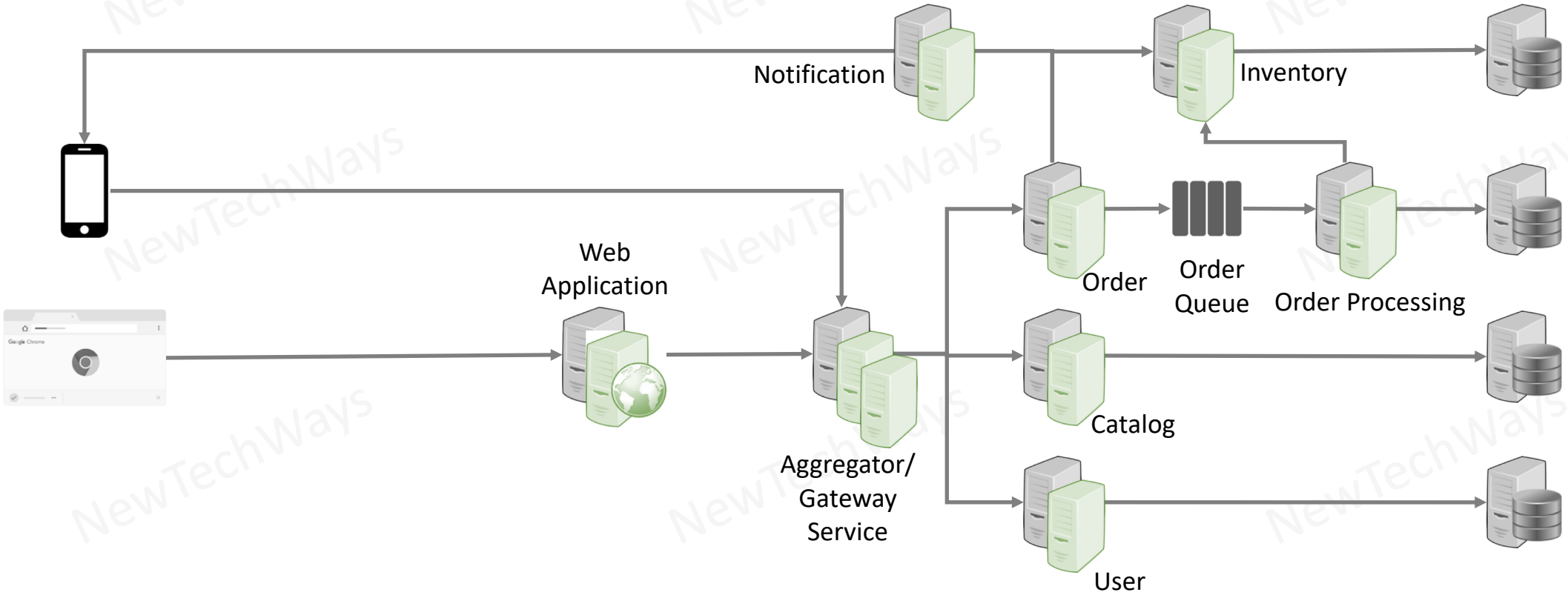
Asynchronous Services

- Updates like order creation, payments can be done asynchronously to control the rate of transactions and the latency of response
  - Brings in complexity to develop and debug



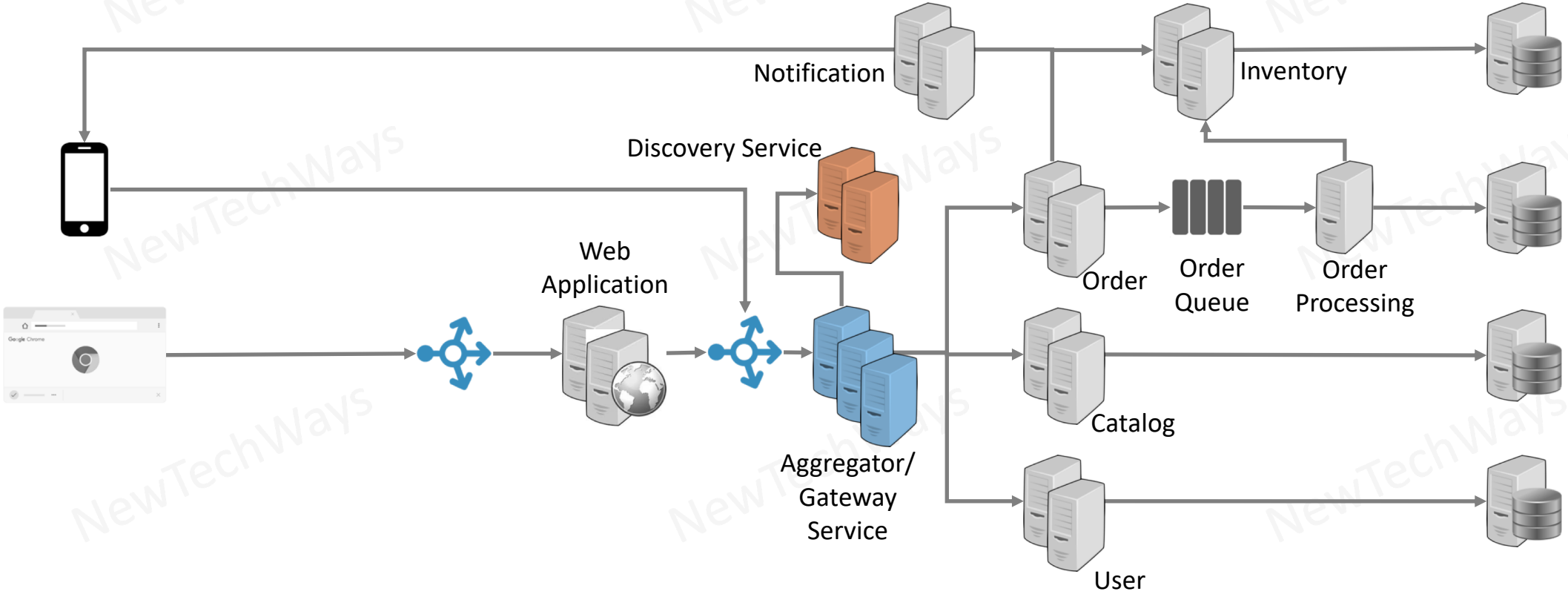
Stateless Replication

- Replication drastically increases computation power
  - Trivial to replicate stateless components
  - Complex considerations for replicating stateful components



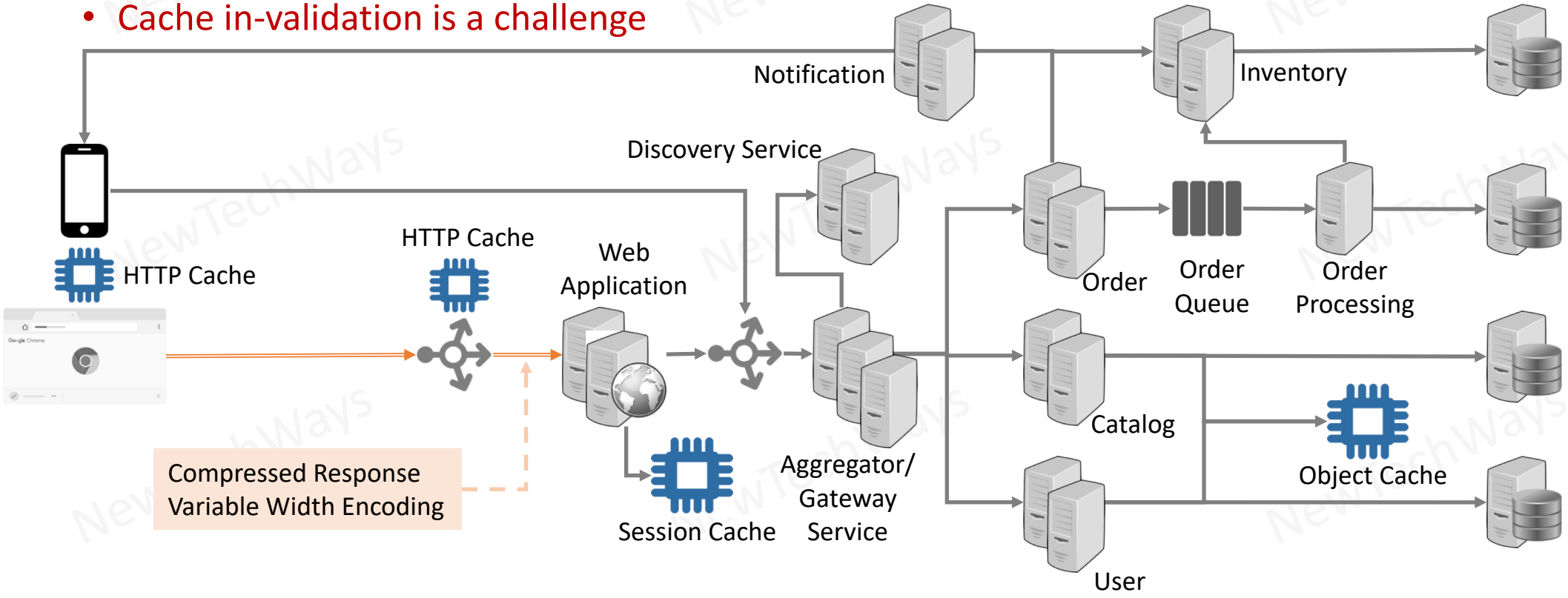
Load Balancing & Discovery

- At this point configuration can not be used for routing requests
  - Load Balancers or Routing Proxy does the routing
  - Discovery services are required to keep track of available services and their healthy instances



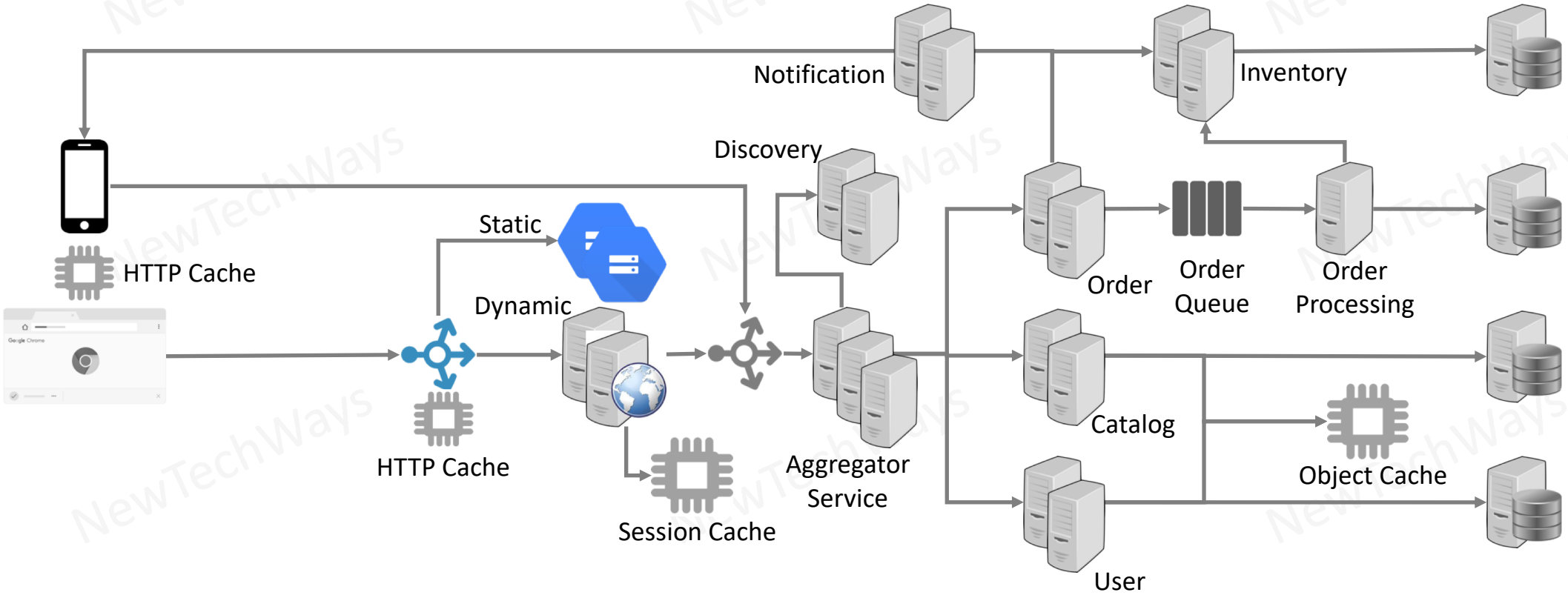
Latency Reduction – Caching & Compression

- Caching not only reduces latency of response but also reduces the load form backend server, thereby making them more scalable
  - Only cache data that is read frequently but doesn't change frequently
  - Cache in-validation is a challenge



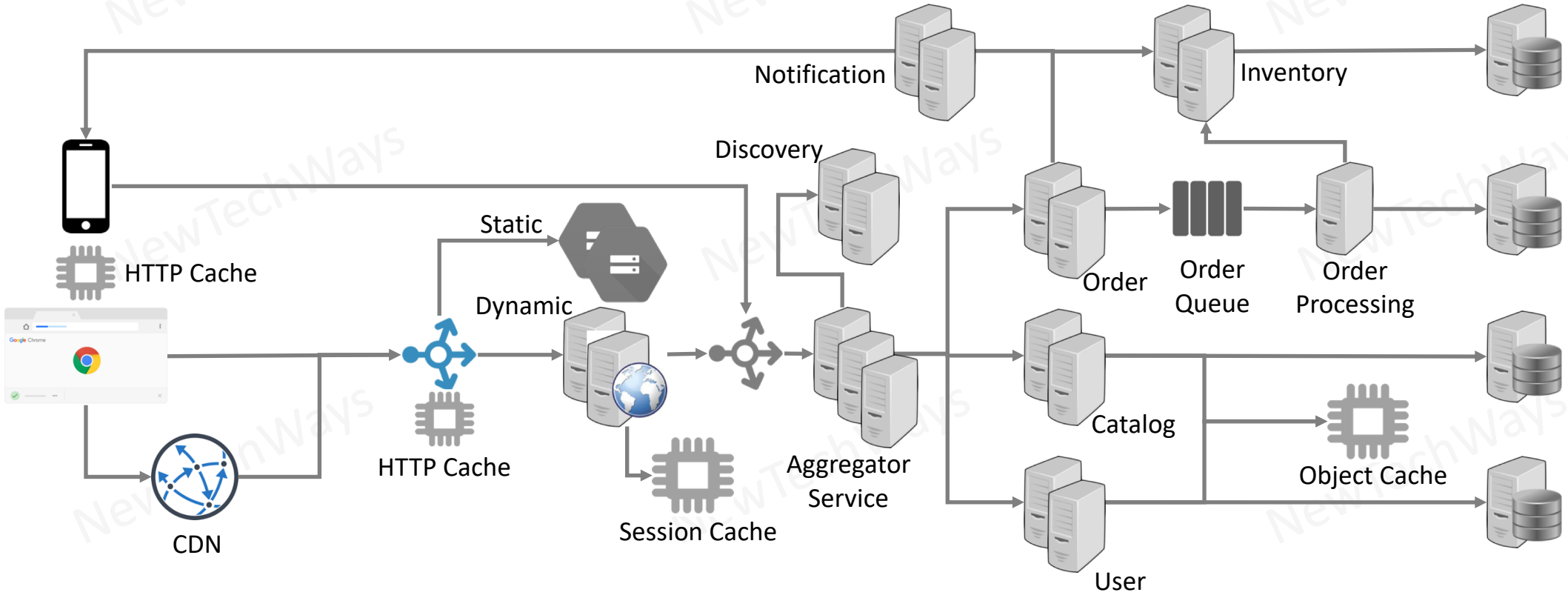
Serving Static Data

- Static Web Data like product images are large in size and are better served through high throughput object stores designed to serve that kind of data
  - LB routing rules can be used to separate dynamic & static content requests



CDN & Edge Proxy

- CDN can be used for caching static web content close to customer location
- Edge Proxy (CDN can act as one) can be used for reducing latency through Early Termination, SSL Termination



Think About It!

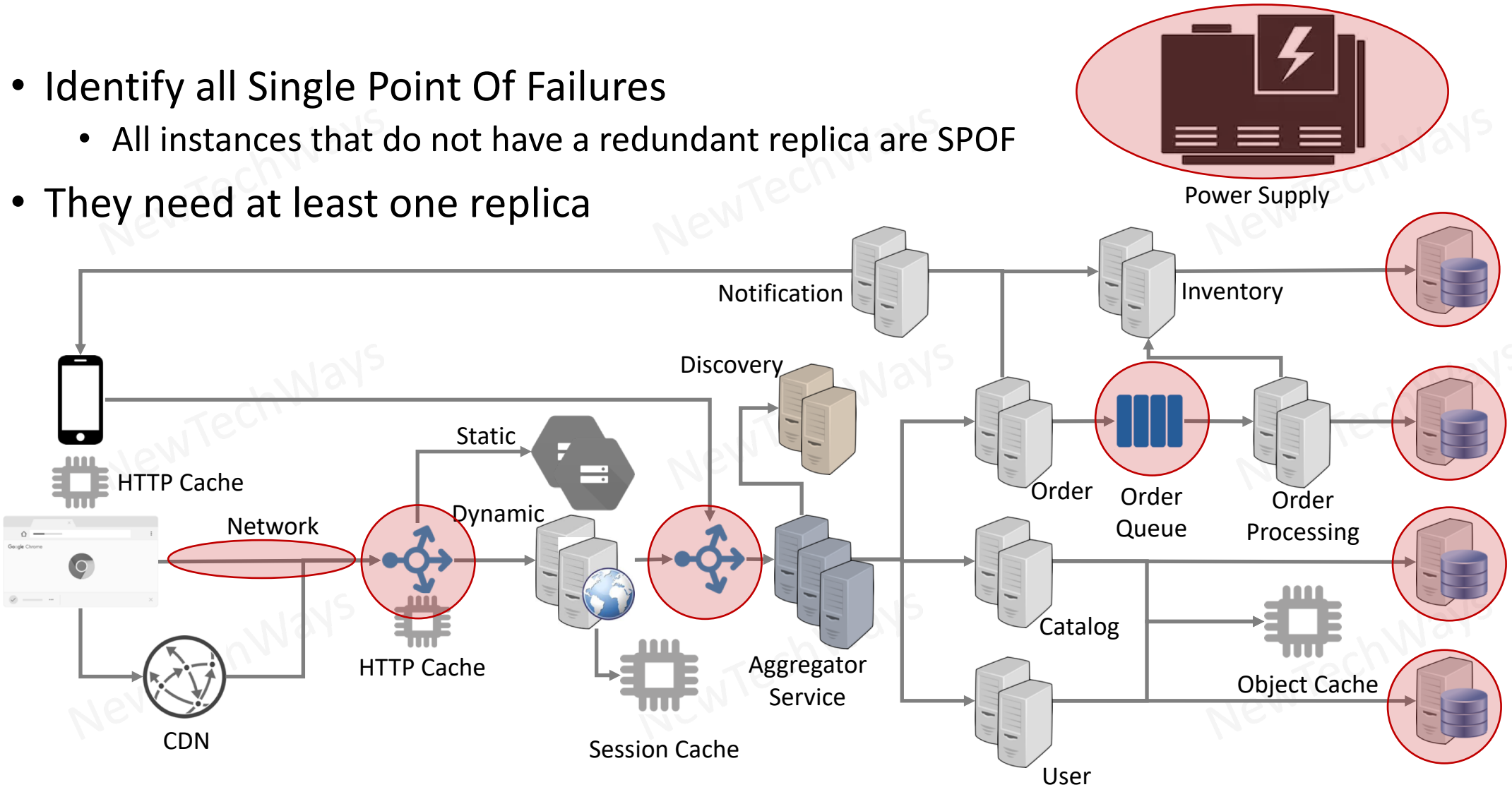
- User Session Management
- Load Balancer
  - Routing & Sessions
  - Types – Software/Hardware, External/Internal
  - Policies
- Back of the Envelope Latency calculations
- RDBMS Scaling Limitations
- NoSQL Vs RDBMS
- Transaction Concurrency
- Eventual Consistency
- Routing for Global Scalability

Reliability Principle

- Reliability
  - Normal functioning even in the presence of faults
- Availability
  - Always available even in the presence of faults
- Reliability and Availability are achieved mainly through Fault Tolerance
- Fault Tolerance requires
  - Provisioning Redundancy
    - Stateless & Stateful
    - Active, Passive, Cold
  - Fault Detection Mechanisms
    - Health-checks, heart-beats
  - Recovery or Failover
    - Stateless & Stateful

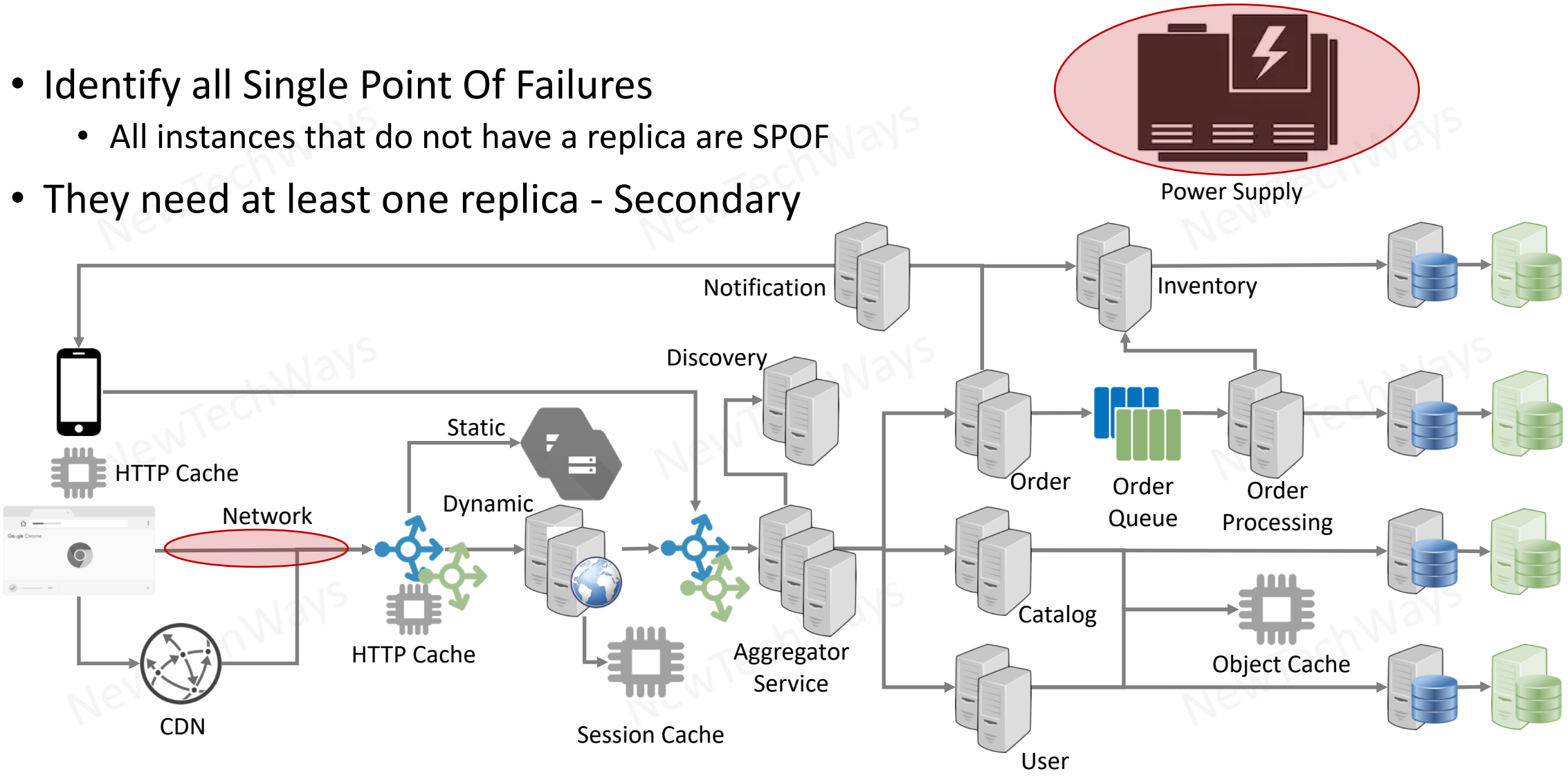
SPOF

- Identify all Single Point Of Failures
  - All instances that do not have a redundant replica are SPOF
- They need at least one replica



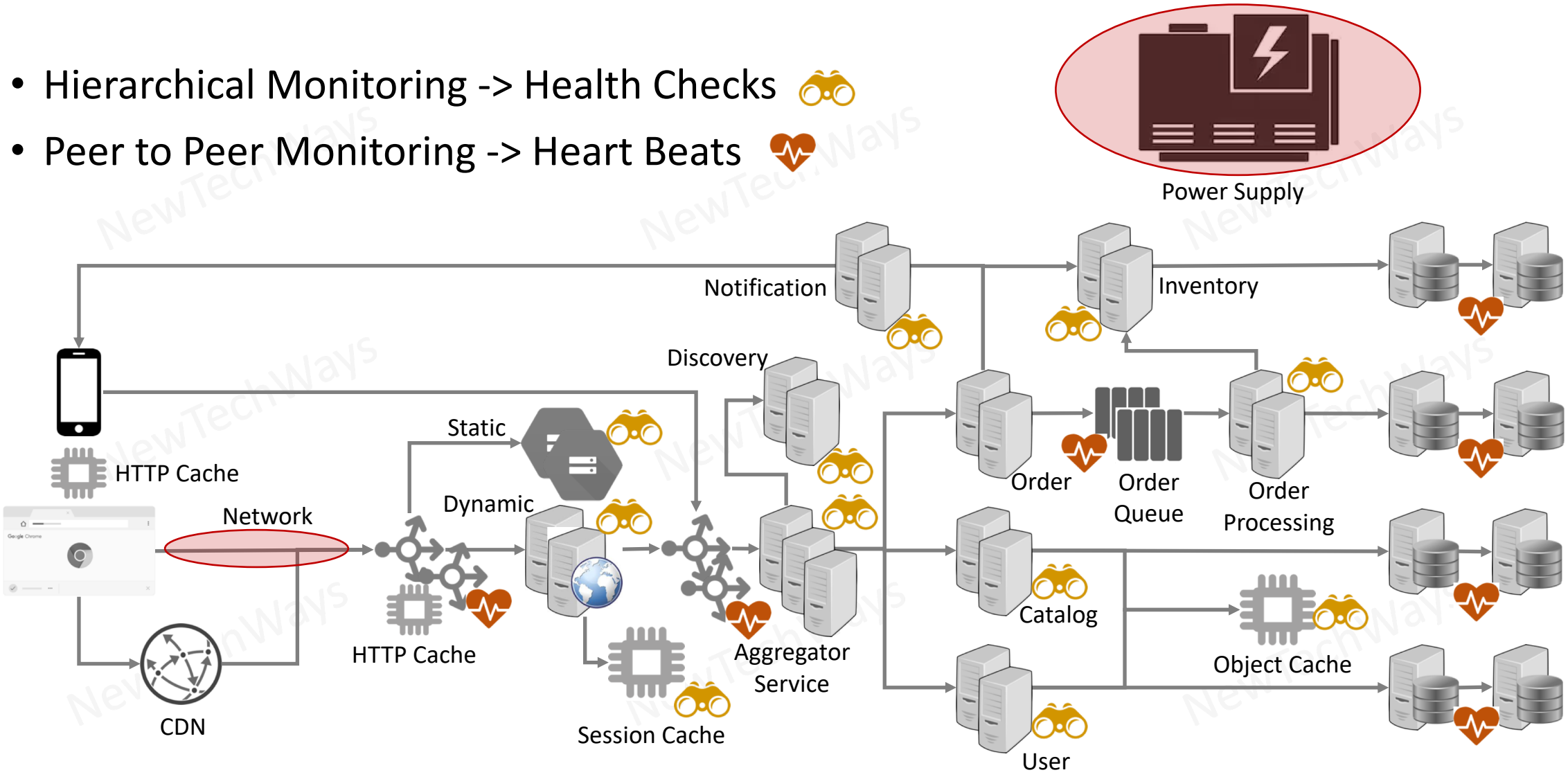
Redundancy

- Identify all Single Point Of Failures
  - All instances that do not have a replica are SPOF
- They need at least one replica - Secondary



Monitoring For Failure

- Hierarchical Monitoring -> Health Checks
- Peer to Peer Monitoring -> Heart Beats



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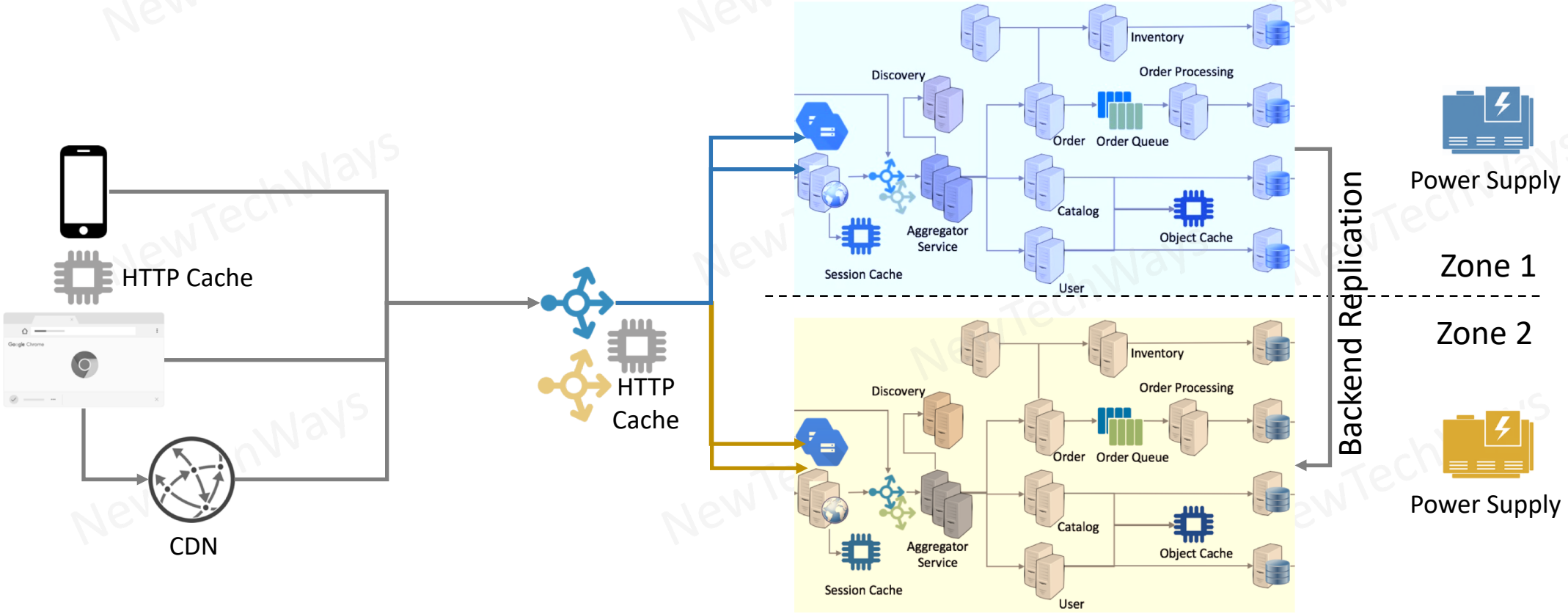
Zonal Redundancy

- Identify all Single Point Of Failures
  - All instances that do not have a replica are SPOF



Think About It!

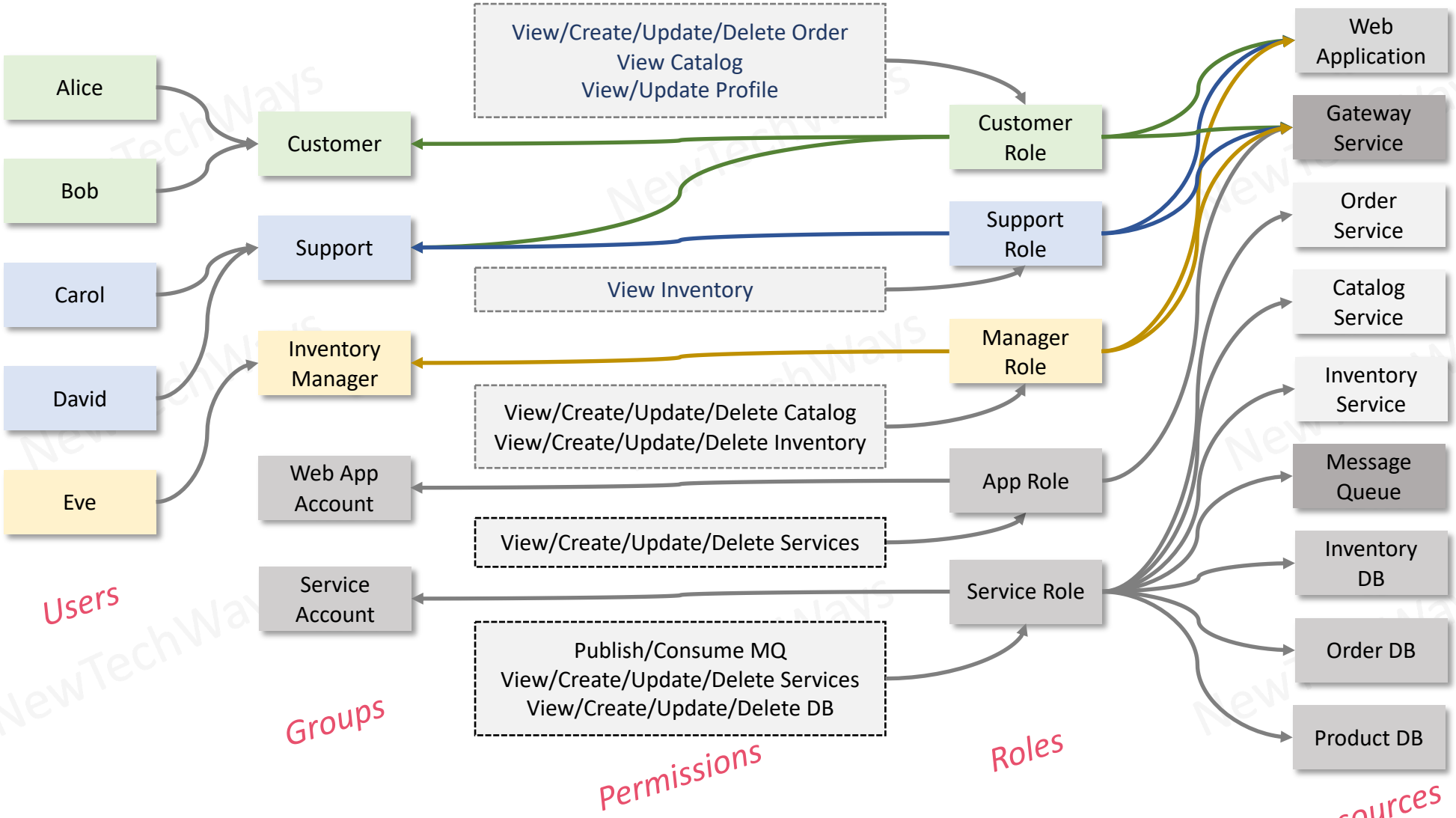
- Zonal Redundancy Routing
- Regional Redundancy & Routing
- Redundancy & Recovery of Stateful Components
- Automated Failover & Recovery
  - Failure Vs Network Partition
  - Magnitude of Failure
- Reliability Practices
  - Retries & Idempotency
  - Graceful handling of errors
  - Controlled service degradation
  - Load Shedding
  - Backpressure

Security Principles

- Least Privilege
  - Minimalistic user access rights just enough to perform a task
- Minimize attack surface area
  - Reduce entry points by authorizing every API request or Activity
    - Allow only minimum set of roles for each API
- Defense In Depth
  - Multiple layered resource access controls
- Separation of Duties
  - Different entities should have different roles
- Fail Secure
  - Failure should not expose more than required information through error messages or logs
- Weakest Link
  - Any system is as strong as its weakest link

OWASP Top 10 - 2017
A1:2017-Injection
A2:2017-Broken Authentication
A3:2017-Sensitive Data Exposure
A4:2017-XML External Entities (XXE) [NEW]
A5:2017-Broken Access Control [Merged]
A6:2017-Security Misconfiguration
A7:2017-Cross-Site Scripting (XSS)
A8:2017-Insecure Deserialization [NEW, Community]
A9:2017-Using Components with Known Vulnerabilities
A10:2017-Insufficient Logging&Monitoring [NEW,Comm.]

Role Based Access Control



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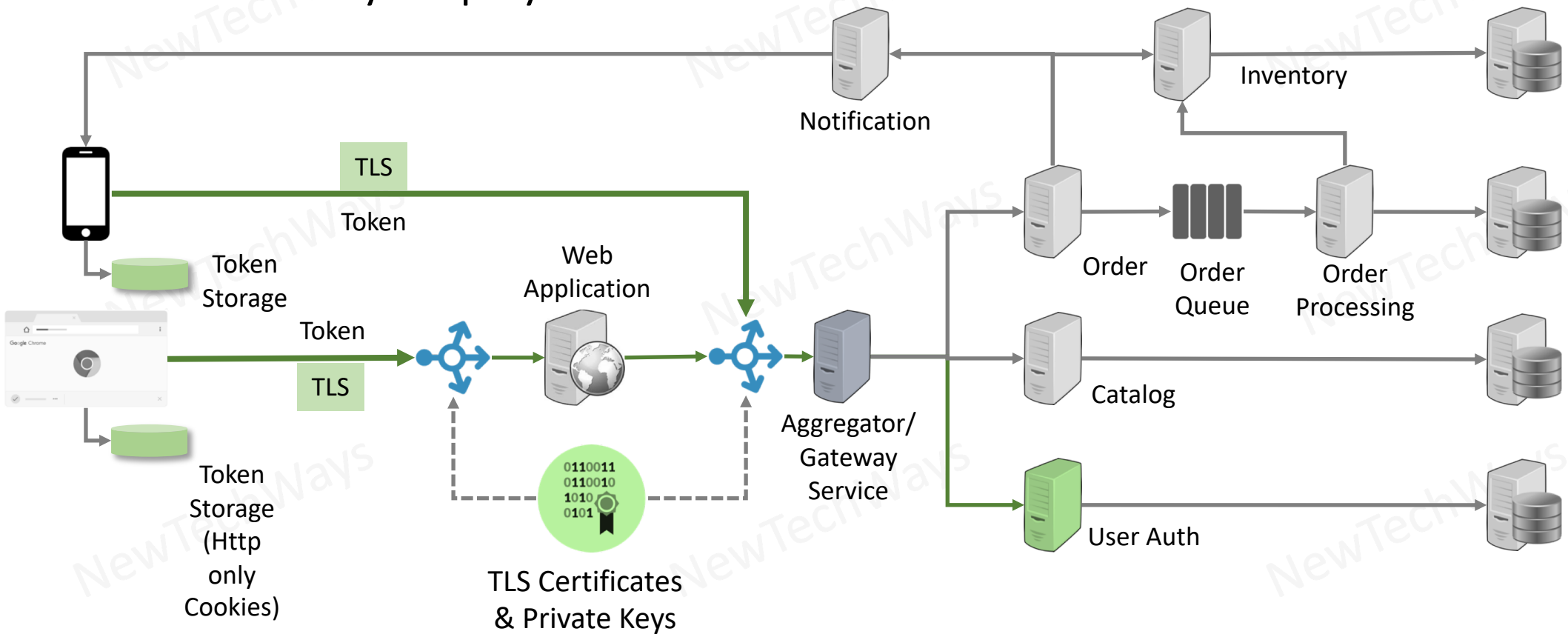
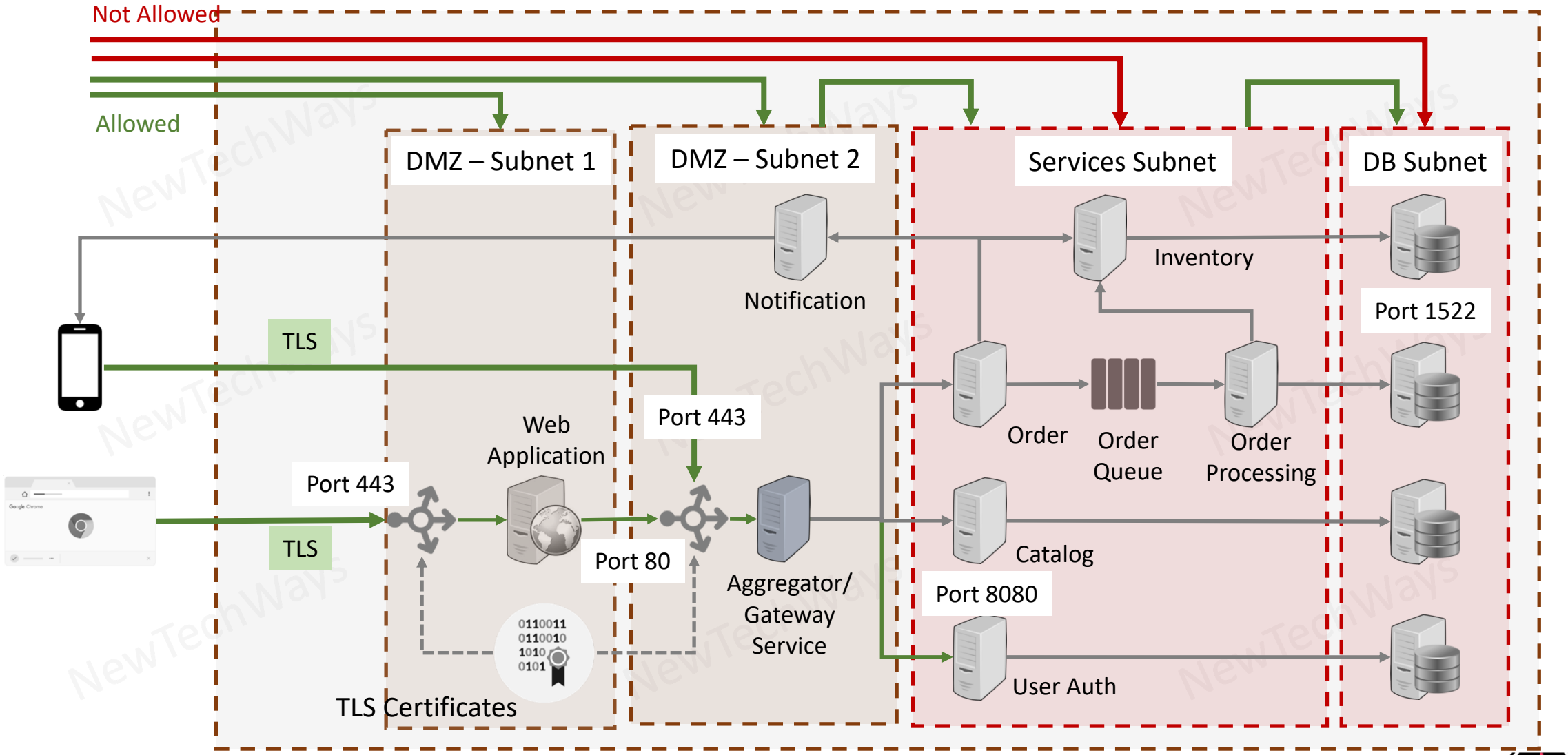
Authentication & Authorization

- Token based authentication over HTTPS
- Certificates & keys deployed on external load balancers



Network Security



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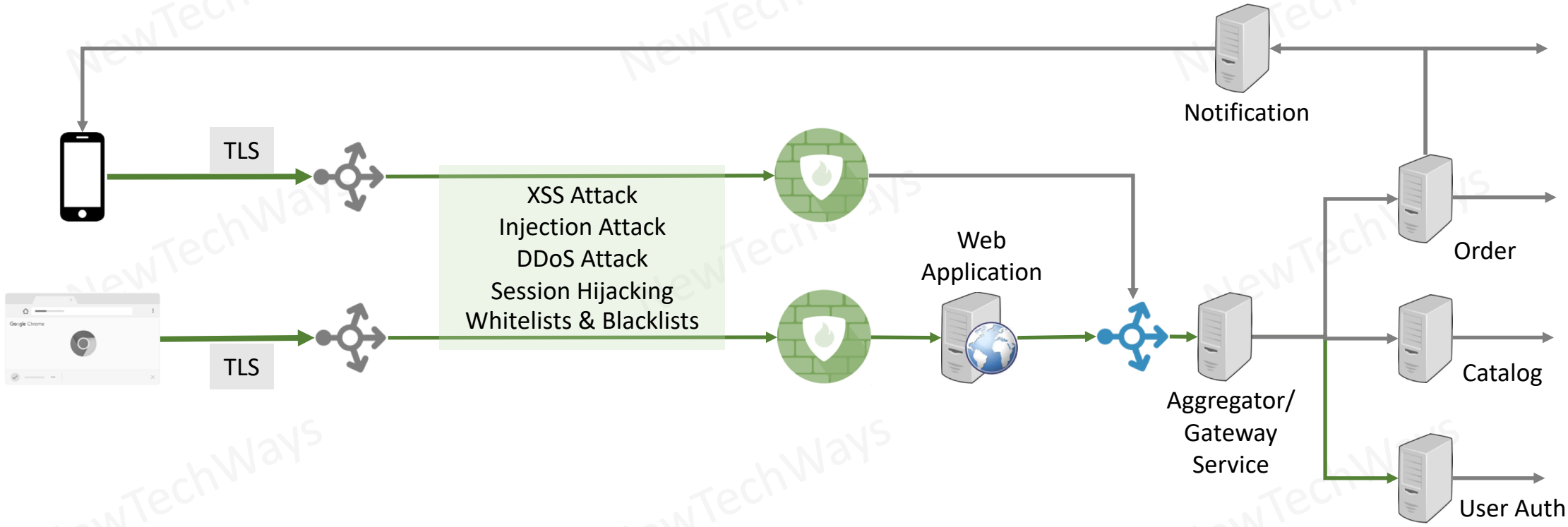
Web Application Firewalls

- Multiple security related attacks can be prevented by inspecting requests for common attacks and vulnerabilities by using Web Application Firewalls



Think About It!

- Security Token Storage
- Stateless & Stateful Authentication
- Third-Party Authorization with OAuth2
- Single Sign On
- TLS Termination
- Common Vulnerabilities
- Stored Data Encryption
- Key Management

That's Just The Beginning

Further challenge lies in the detail

And we have sorted it out for you

If you are an Architect or a Developer

And you want to bridge the gap between

A Great Developer and a True Architect

You should enroll yourself to 'NewTechWays' course

'Developer To Architect'

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