Architecting A Cloud-native Data Analysis Application for ETDs

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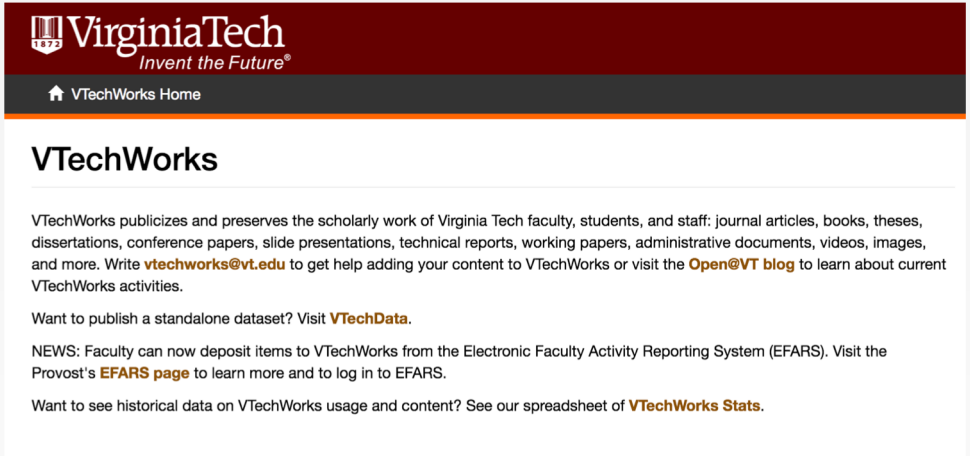
VIRGINIA TECH

Agenda

- ***Introduction***
- Monolithic vs. Cloud-native applications
- Cloud-native approach
- Data analytics architecture
- Future work

VTechWorks

- Research Documents
  - 60,000+ scholarly works
  - Inc. 30,000+ ETDs
- Using DSpace
  - Open digital repository
  - Open source project
  - Monolithic architecture



DSPACE

DURASPACE™

Problems

- Need for advanced analytics functionalities
  - Customizable
  - Visualization
  - Usable and flexible user interface (UI)
- Extending existing codebase is a difficult task.
  - Customization that meets community needs is rare.
  - Version update will lose or break customized functionalities.

From Research Dataset to Visualization

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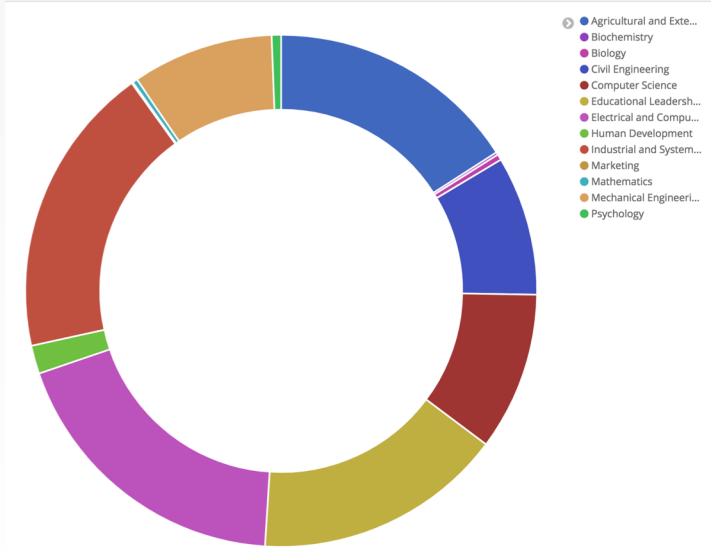

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From Log Data to Visualization


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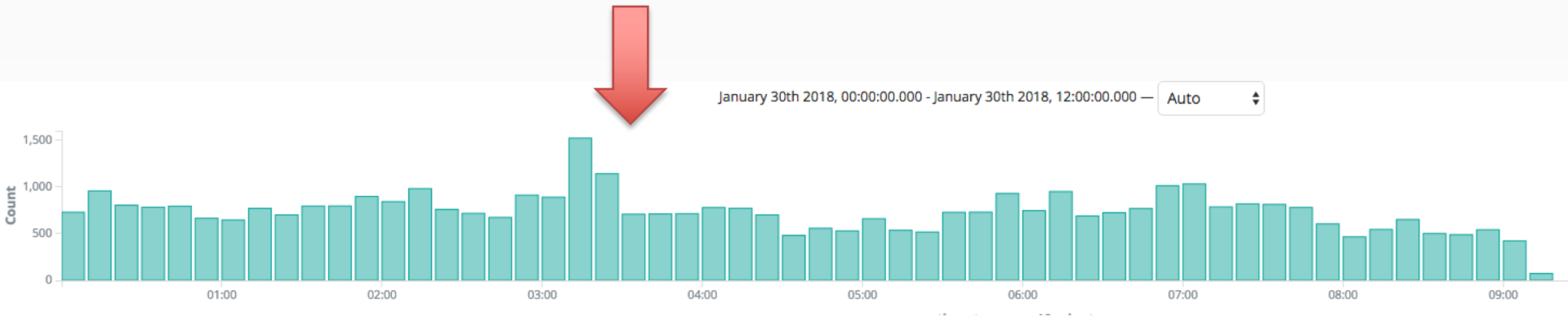

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- Introduction
- ***Monolithic vs. Cloud-native applications***
- Cloud-native approach
- Data analytics architecture
- Future work

Monolithic Architecture

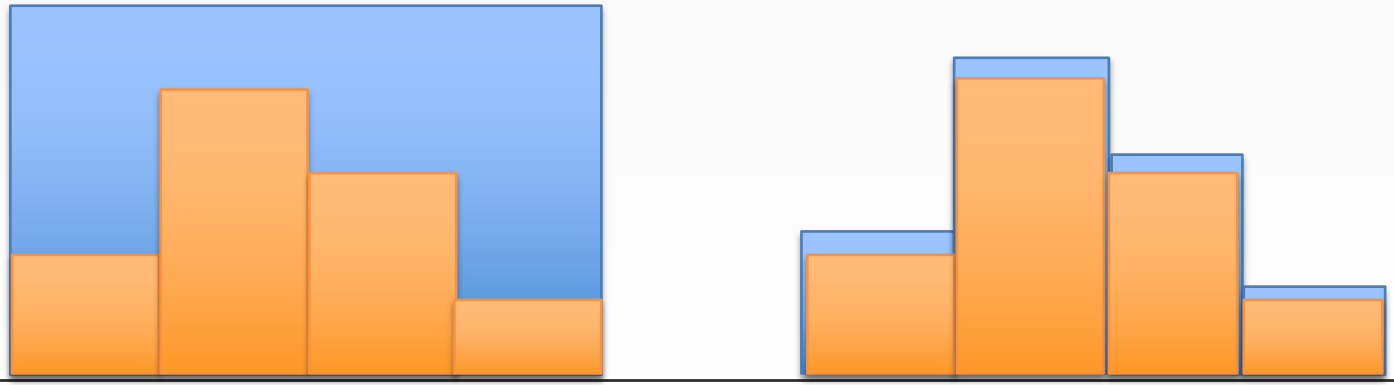
- Develop and deploy as a single unit
- Often requires human intervention
- Long-term commitment to a technology stack or even version
- Hard to scale development
- Difficult to scale the application

Why Towards Cloud Native

- Limited resources:
  - Developers, DevOps, Infrastructure, Time
- Reduce need to build everything from scratch
- Use services that can help deliver the project
- Facilitate the development process
- Provide better services: fault-tolerant, auto-scale, update/rollback without downtime, etc.
- Optimize resource utilization

Resource Usage Optimization and Automation

- Consume only the required resources for the applications
- Scale up and down automatically
- Service and function oriented, not server oriented
- Utilize cloud services to help understand applications (CloudWatch, Auto Scaling, Trusted Advisor, etc.)



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What is Cloud Native?

It is not just putting applications in the cloud.

It is about building applications in the cloud that utilize the **advantages** provided by the cloud

AS MUCH AS POSSIBLE.

Cloud Native

- Cloud Native Computing Foundation (CNCF)
  - An open source software foundation dedicated to making cloud native computing universal and sustainable
- Microservices oriented
- Containerized
- Dynamically orchestrated

Microservices oriented

Microservice

- Small software piece
- Messaging enabled – communicate with messages
- Decentralized
  - Autonomously developed
  - Independently deployable
  - Can change independently of each service
  - Scale individually by load
- Built and released with automated processes
- More complex architecture

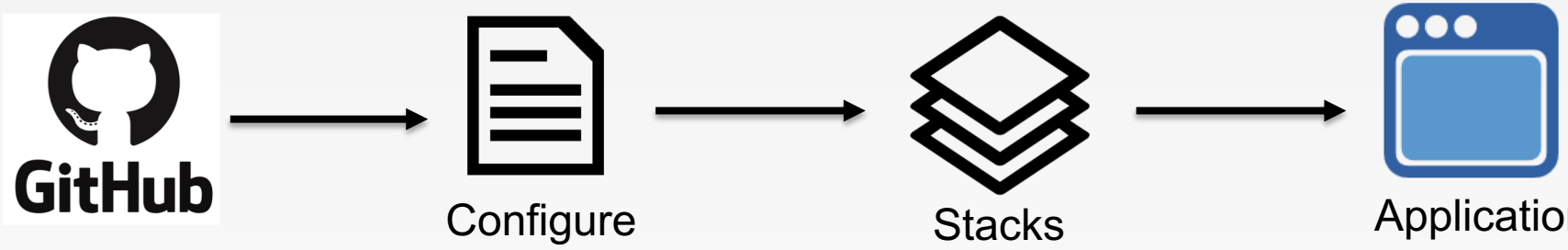
Serverless

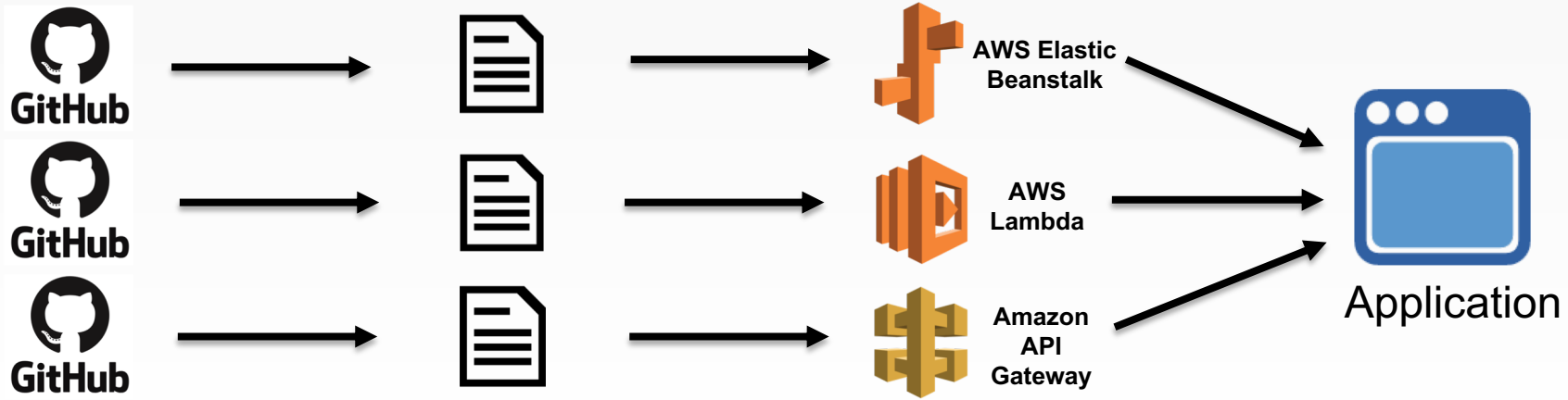
Does not mean “There are no servers at all”.

Does mean “Use fully managed services”.

Focus on application development,
not server maintenance

Parallel Development and Deployment





Containerized

Containerization

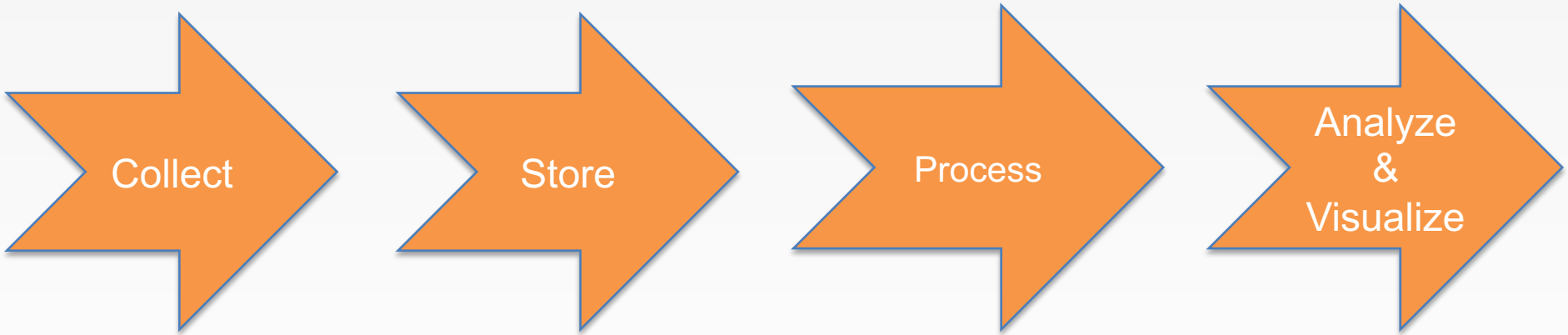
- BaaS (Backend as a Service), CaaS (Container as a Service), and FaaS (Function as a Service)
- Best practice is each service in its own isolated environment, e.g., Docker container.
- But a container can run multiple services, or an entire application.
- Everything at Google runs in a container
  - 4 Billion containers per week in 2018

Dynamically orchestrated

Orchestration

- Infrastructure as Code
- Automatic deployment and operation
- Optimize resource utilization dynamically

Data Analytics Pipeline



Design Pattern and Best Practice

- The Twelve-Factor App (http://12factor.net)

Codebase	Dependencies	Config
Backing services	Build, release, run	Processes
Port binding	Concurrency	Disposability
Dev/prod parity	Logs	Admin processes

Design Strategies

- Microservices
- Containers
- Orchestration

- Serverless (managed service)
- Scalability
- Automation
- Optimization (resource usage, cost, etc.)

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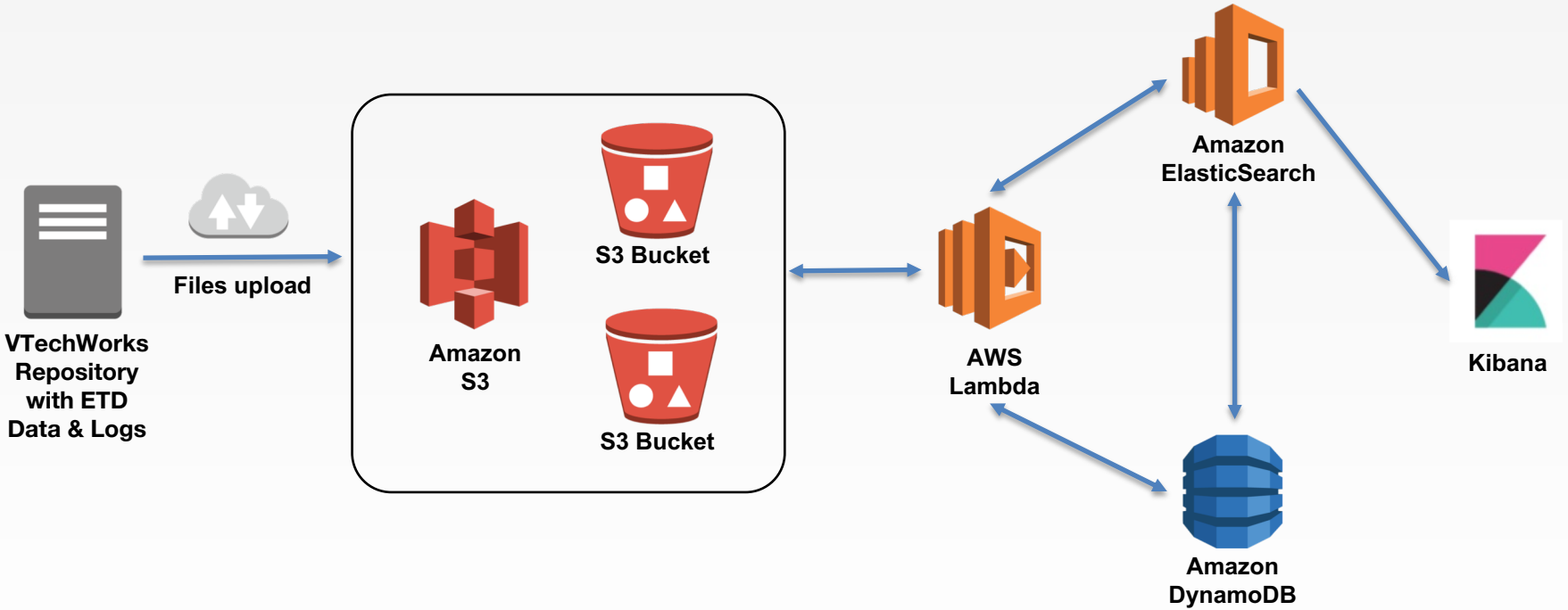
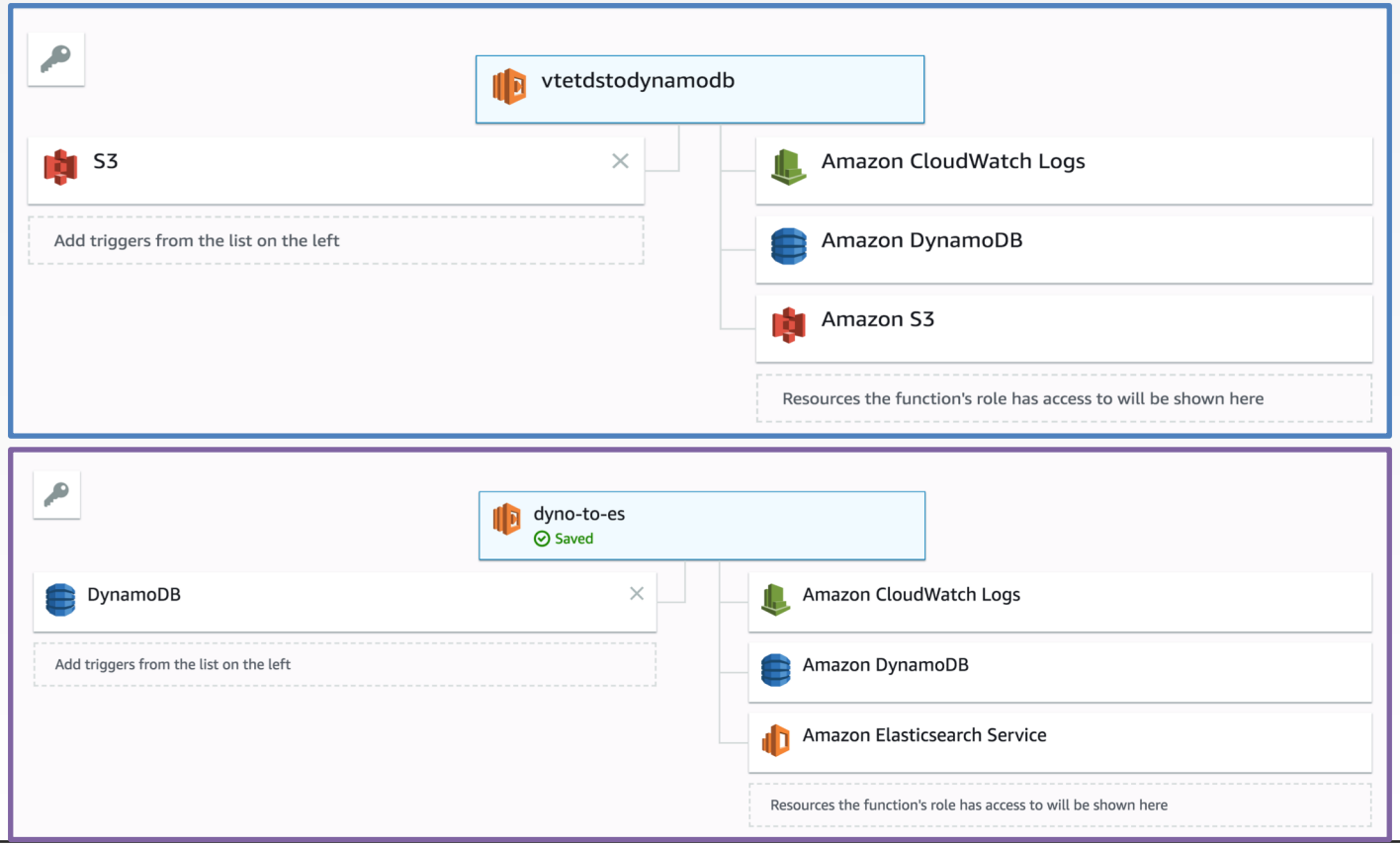
Application Architecture Overview



AWS Services

- AWS S3: Object storage in the cloud
- AWS Lambda: Serverless compute platform for stateless code execution in response to events
- Amazon Dynamodb: Fully managed NoSQL database service
- Amazon ElasticSearch: Search engine based on Lucene
- Kibana: An open source data visualization plugin for ElasticSearch

Microservice – Using AWS Lambda



Metadata Transformation Using AWS Lambda

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  Society, Cancer is the second most common cause of death in the United States, only exceeded by heart
  disease. Over the past decade, deciphering the complex structure of individual cells and understanding the
  symptoms of cancer disease has been a highly emphasized research area. The exact cause of Cancer and the
  genetic heterogeneity that determines the severity of the disease and its response to treatment has been a
  great challenge. Researchers from the engineering discipline have increasingly made use of recent
  technological innovations, namely the Atomic Force Microscope (AFM), to better understand cell physics and
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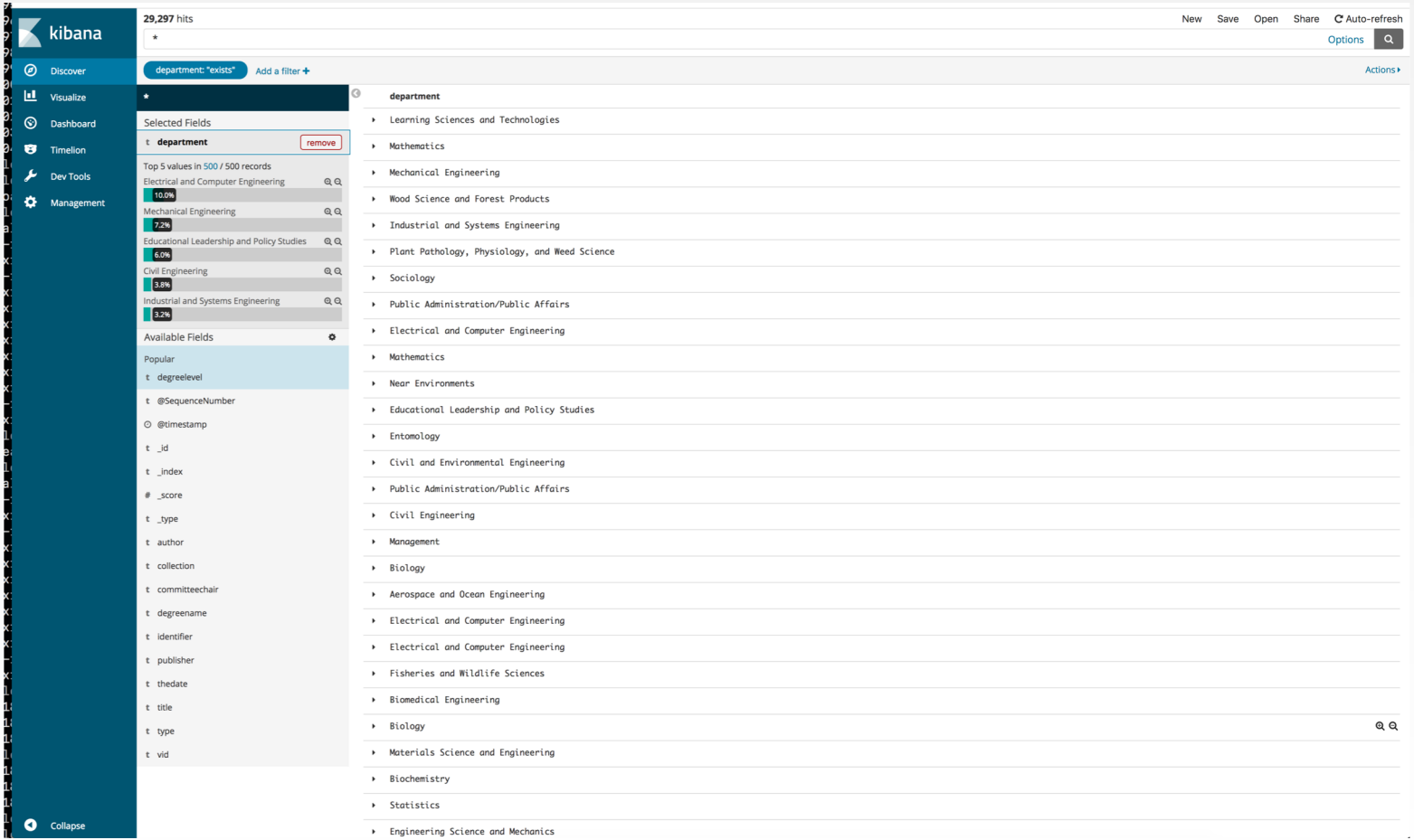
Visualization – Kibana



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Results

- Facilitate application development
  - Parallel development and deployment
  - Switch services or techniques more flexibly
- Decouple the data analytics pipeline
  - More complex architecture and testing setup
  - More things to learn in order to select right tools
- Delegate maintenance tasks to cloud providers

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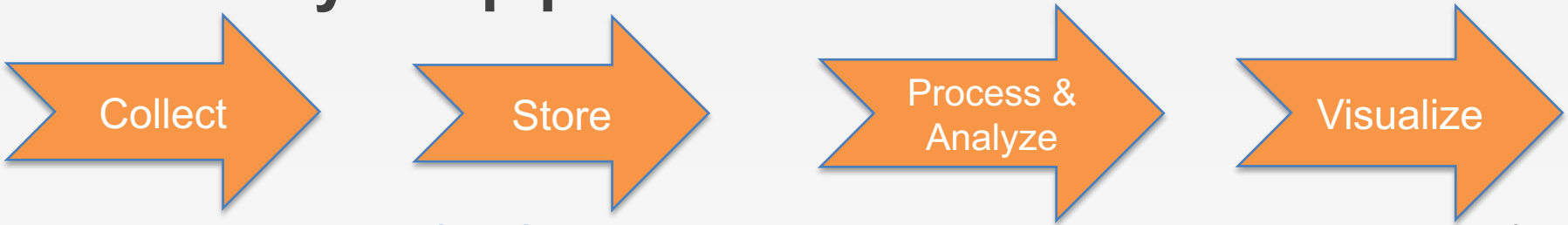
Data analytics pipeline in AWS



Real-time
Amazon Kinesis Firehose

Data Import
Amazon Import/Export Snowball

Message Queuing
Amazon SQS

Web/app Servers
Amazon EC2

Object Store
Amazon S3
Amazon Glacier

Real-time
Amazon Kinesis Streams

RDBMS
Amazon RDS

NoSQL
DynamoDB

Search
Amazon CloudSearch

IoT
Amazon IoT

Hadoop Ecosystem
Amazon EMR

Real-time
AWS Lambda
Amazon Kinesis Analytics

Data Warehousing
Amazon Redshift

Machine Learning
Amazon Machine Learning

Elastic Search Analytics
Amazon ElasticSearch

Process & Move Data
AWS Data Pipeline

Business Intelligence & Data Visualization
Amazon QuickSight

Elastic Search Analytics
Amazon ElasticSearch

Blue: current
Green: alternate
Black: other possible

Cloud Native Data Analysis Platform in AWS

IAM

AWS Organizations

Security & Identity

AWS Lambda

Amazon DynamoDB

Amazon ElasticSearch

Compute & Database

Amazon S3

Amazon Glacier

Storage

Kibana

*Amazon Athena

*Amazon Machine Learning

Analytics

AWS CLI

AWS CloudFormation

AWS CloudTrail

AWS Trusted Advisor

Amazon CloudWatch

AWS Config

Management

Other Cloud Platforms

- Amazon Web Services (AWS) - done
- Google Cloud Platform (GCP) – easily done
- Microsoft Azure, etc. – also possible

AWS	GCP	Azure
Elastic Compute Cloud	Compute Engine	Virtual Machines
Elastic Beanstalk	Google App Engine	Cloud Services
EC2 Container Service Kubernetes (EKS)	Kubernetes Engine	Container Service (AKS)
Lambda	Cloud Functions	Functions
Simple Storage Services	Cloud Storage	Storage
Virtual Private Cloud	Virtual Private Cloud	Virtual Network

Q & A

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Thank You!