

BENR2423

# Database and Cloud System

Chapter 1:  
Introduction

# Contact



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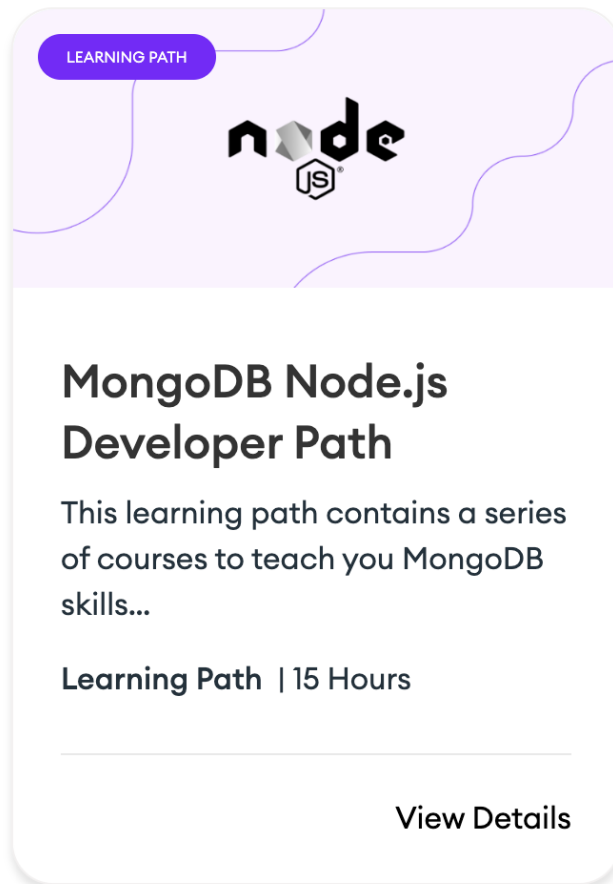
**soo@utem.edu.my**



**Research Lab III**

- Course Work: 40%
  - Quiz: 5%
  - Test: 15%
  - Assignment: 20%
- Final Exam: 60%
- MongoDB Associate Developer Exam: 5%

Grading



A learning path card for MongoDB Node.js Developer Path. The top section has a purple background with the Node.js logo and the text 'LEARNING PATH' in a purple pill. Below this, the title 'MongoDB Node.js Developer Path' is displayed in a large, bold font. A paragraph describes the path as a series of courses to teach MongoDB skills. The duration 'Learning Path | 15 Hours' is shown below. A 'View Details' button is at the bottom right.

LEARNING PATH

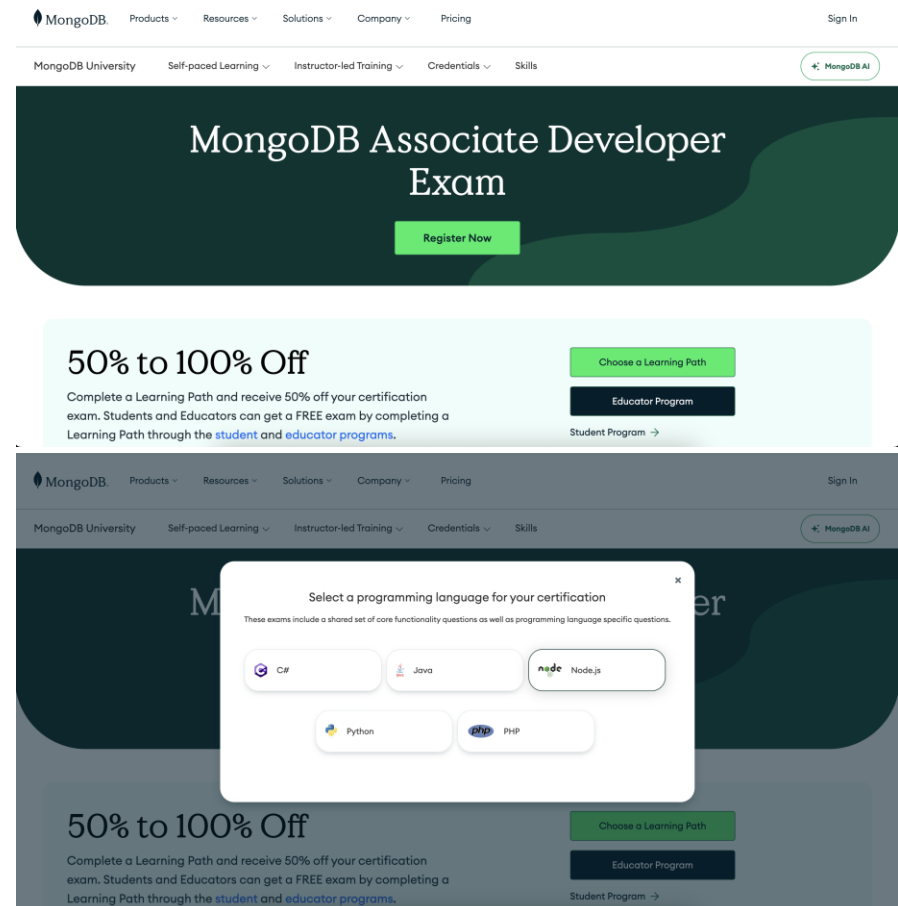
**MongoDB Node.js Developer Path**

This learning path contains a series of courses to teach you MongoDB skills...

Learning Path | 15 Hours

View Details

<https://learn.mongodb.com/learning-paths/mongodb-nodejs-developer-path>



A screenshot of the MongoDB Associate Developer Exam page. The top navigation bar includes links for Products, Resources, Solutions, Company, and Pricing. The main heading is 'MongoDB Associate Developer Exam' with a 'Register Now' button. Below this, a promotional banner offers '50% to 100% Off' for completing a learning path. A modal window is open, titled 'Select a programming language for your certification', showing options for C#, Java, Node.js (selected), Python, and PHP. The bottom section repeats the promotional banner.

MongoDB. Products Resources Solutions Company Pricing Sign In

MongoDB University Self-paced Learning Instructor-led Training Credentials Skills MongoDB AI

# MongoDB Associate Developer Exam

Register Now

50% to 100% Off

Complete a Learning Path and receive 50% off your certification exam. Students and Educators can get a FREE exam by completing a Learning Path through the [student](#) and [educator](#) programs.

Choose a Learning Path

Educator Program

Student Program →

Select a programming language for your certification

These exams include a shared set of core functionality questions as well as programming language specific questions.

C# Java **node Node.js** Python PHP

50% to 100% Off

Complete a Learning Path and receive 50% off your certification exam. Students and Educators can get a FREE exam by completing a Learning Path through the [student](#) and [educator](#) programs.

Choose a Learning Path

Educator Program

Student Program →

<https://learn.mongodb.com/pages/mongodb-associate-developer-exam>

# MongoDB Associate Developer Exam

- Database Design and Queries
- Fundamental Backend Development
- Edge to Cloud Communication Protocol

Course Topics

## Platform

- Mongo Atlas
  - <https://account.mongodb.com/account/login>
- Microsoft Azure
  - <https://azure.microsoft.com/en-us>
- Github
  - <https://github.com/>

## Framework

- MongoDB
  - <https://www.mongodb.com/>
- NodeJs
  - <https://nodejs.org/en/>

## Programming Language

- JavaScript

# Programming and Tools

# Tools

- MongoDB Compass
  - <https://www.mongodb.com/try/download/compass>
- Microsoft Visual Studio Code
  - <https://code.visualstudio.com/>
- Postman
  - <https://www.postman.com/>
- Git
  - <https://git-scm.com/downloads/win>
- Wireshark
  - <https://www.wireshark.org/>

# Week 1

- **Lab 1 – Environment Setup & Introduction to MongoDB**

- **Objectives:**

- Install and configure essential development tools (VSCode, NodeJS, Git, and MongoDB)
    - Familiarize with the MongoDB shell and Compass for basic database interactions

- **Activities:**

- Set up the development environment and install required software
    - Create a simple “Hello World” NodeJS project that connects to MongoDB
    - Explore sample databases using both the command line and MongoDB Compass



# Week 2

- **Lab 2 – Basic MongoDB CRUD Operations & Query Language**
  - **Objectives:**
    - Master MongoDB's CRUD operations using its native query language
    - Utilize MongoDB Compass and CLI to manipulate data
  - **Activities:**
    - Insert, query, update, and delete sample documents in a collection
    - Develop basic queries and filters using the MongoDB query language

# Week 3

- **Lab 3 – Building a Basic REST API with NodeJS and MongoDB**
  - **Objectives:**
    - Introduce Express.js for building RESTful services
    - Integrate MongoDB operations within a NodeJS server environment
    - Validate endpoints using Postman
  - **Activities:**
    - Scaffold a NodeJS/Express project and establish API routes for a “users” collection
    - Implement endpoints that perform CRUD operations integrated with MongoDB
    - Test endpoints using Postman and capture the results

# Week 4

- **Lab 4 – HTTP Protocols, API Design Fundamentals & Wireshark TCP Stream Analysis**
  - **Objectives:**
    - Deepen understanding of HTTP methods (GET, POST, PUT, DELETE) and status codes
    - Introduce API design best practices, including the creation of API flow diagrams
    - Learn to use Wireshark to capture and analyze TCP streams corresponding to HTTP transactions
  - **Activities:**
    - Capture HTTP request/response sequences using Wireshark with a focus on the TCP stream
    - Generate a Wireshark sequence diagram to visualize the TCP handshake, HTTP request/response flow, and correlate these activities with the designed API flow
    - Refactor existing endpoints to align with best practices based on the analysis

# Week 5

- **Lab 5 – Implementing JWT Authentication**

- **Objectives:**

- Secure the REST API with JSON Web Tokens (JWT)
    - Implement role-based access control (RBAC) in a multi-role system

- **Activities:**

- Integrate JWT into the NodeJS application for user authentication
    - Develop middleware to protect routes and manage roles (e.g., customer, driver, admin)
    - Test secure endpoints using Postman with both valid and invalid tokens

# Week 6:

- **Lab 6 – Deep Dive into the MongoDB Aggregation Framework**
  - **Objectives:**
    - Master the aggregation pipeline for complex data queries in MongoDB
    - Understand key stages such as \$match, \$group, \$sort, and \$project
  - **Activities:**
    - Create aggregation queries to produce summary reports (e.g., user statistics)
    - Compare aggregation query results with standard query methods
    - Visualize the aggregation pipeline using MongoDB Compass

# Week 7

- **Lab 7 – Database Indexing and Performance Optimization**

- **Objectives:**

- Learn to implement indexing in MongoDB to enhance query performance
    - Utilize performance analysis tools and explain plans to refine queries

- **Activities:**

- Create indexes on collections and evaluate their impact using MongoDB's explain plan
    - Conduct performance tests and adjust queries/indexes accordingly

# Week 8

- **Lab 8 – Database Design: ERD & Crow's Foot Notation**
- **Objectives:**
  - Understand fundamental database design principles using ER diagrams and crow's foot notation
  - Develop a robust schema for a ride-sharing system scenario
- **Activities:**
  - Design an ERD that models multi-role interactions in a ride-sharing system
  - Discuss normalization and relationships between entities
  - Translate the ERD into a MongoDB schema design, identifying collections and document relationships

# Week 9

- **Lab 9 – Advanced NodeJS: Multi-role Architecture and API Enhancements**
- **Objectives:**
  - Expand the API to support a multi-role system (customer, driver, admin)
  - Refine API design with enhanced route structuring and detailed flow diagrams
- **Activities:**
  - Implement additional role-specific endpoints and middleware for role validation
  - Update API flow diagrams to clearly outline the request handling process for each role
  - Refactor the NodeJS codebase for improved scalability and maintainability



# Week 10

- **Lab 10 – Introduction to CI/CD with GitHub Actions**
  - **Objectives:**
    - Grasp continuous integration/continuous deployment (CI/CD) principles
    - Configure GitHub Actions to automate testing, linting, and builds
  - **Activities:**
    - Set up a GitHub repository for the NodeJS project
    - Create GitHub Actions workflows that trigger on pushes and pull requests
    - Analyze build logs and refine the CI pipeline configuration

# Week 11

- **Lab 11 – Cloud Deployment on Microsoft Azure**

- **Objectives:**

- Introduce Microsoft Azure services for web app hosting
    - Deploy the NodeJS application to Azure using automated pipelines

- **Activities:**

- Create an Azure Web App and configure the necessary deployment settings
    - Integrate GitHub Actions with Azure deployment pipelines
    - Monitor the deployed application and resolve common deployment issues

# Week 12

- **Lab 12 – Debugging, Logging, and Enhanced Wireshark TCP Stream Analysis**

- **Objectives:**

- Improve debugging and logging skills using VSCode's debugging tools
- Use Wireshark to capture and analyze the TCP stream in detail, focusing on debugging and network issues
- Correlate the captured TCP stream with activities shown in a Wireshark sequence diagram

- **Activities:**

- Set breakpoints and step through the NodeJS application using VSCode
- Capture live HTTP/TCP traffic using Wireshark, applying TCP stream filtering
- Generate a detailed Wireshark sequence diagram and analyze it based on the specific activities (e.g., TCP handshake, data exchange, error handling) observed during the lab

# Week 13

- **Lab 13 – Mini Project: Building a Ride-Hailing API Subsystem**
- **Objectives:**
  - Integrate the skills acquired in previous labs to construct a core ride-hailing API subsystem
  - Emphasize API design, database integration, security, and performance optimization
- **Activities:**
  - Develop endpoints for booking rides, managing users, and assigning drivers
  - Implement JWT authentication and role validation within the subsystem
  - Produce supporting documentation including ERDs, API flow diagrams, and a Wireshark sequence diagram (if applicable) to validate API behavior

# Week 14

- **Lab 14 – Capstone Project: Develop a Grab-like Solution**

- **Objectives:**

- Consolidate all learned concepts into a comprehensive, full-stack ride-hailing application
- Demonstrate professional-level software development, including security, scalability, and continuous deployment practices

- **Activities:**

- Design and implement a full-fledged ride-hailing application with multi-role support (customers, drivers, admins)
- Develop secure REST APIs using JWT, design robust MongoDB schemas with proper indexing and aggregation, and apply CI/CD pipelines using GitHub Actions for automated deployment to Azure
- Prepare detailed design documents including ERDs, API flow diagrams, and Wireshark sequence diagrams to illustrate TCP stream analyses during critical operations
- Present and demo the complete solution in a final presentation

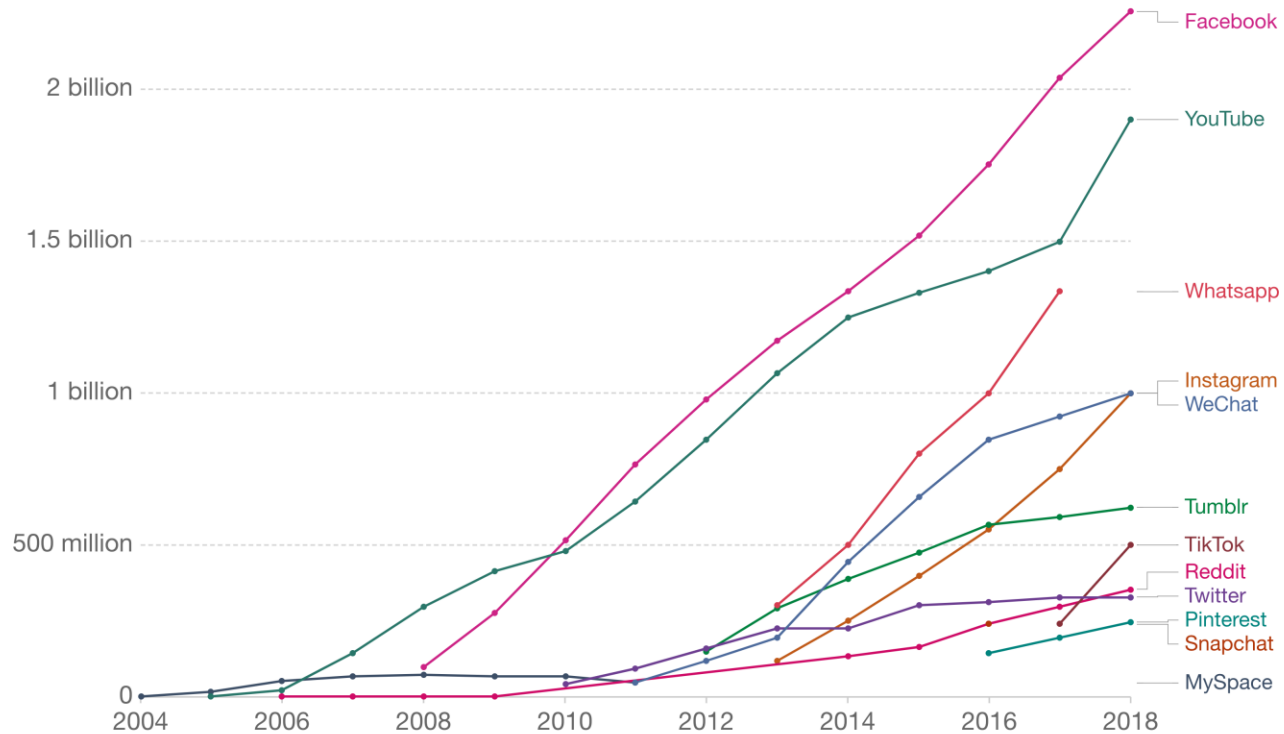
# Introduction to Database

## Chapter 1

- The world is drowning in data

## Number of people using social media platforms, 2004 to 2018

Estimates correspond to monthly active users (MAUs). Facebook, for example, measures MAUs as users that have logged in during the past 30 days. See source for more details.



Source: Statista and TNW (2019)

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# Motivation



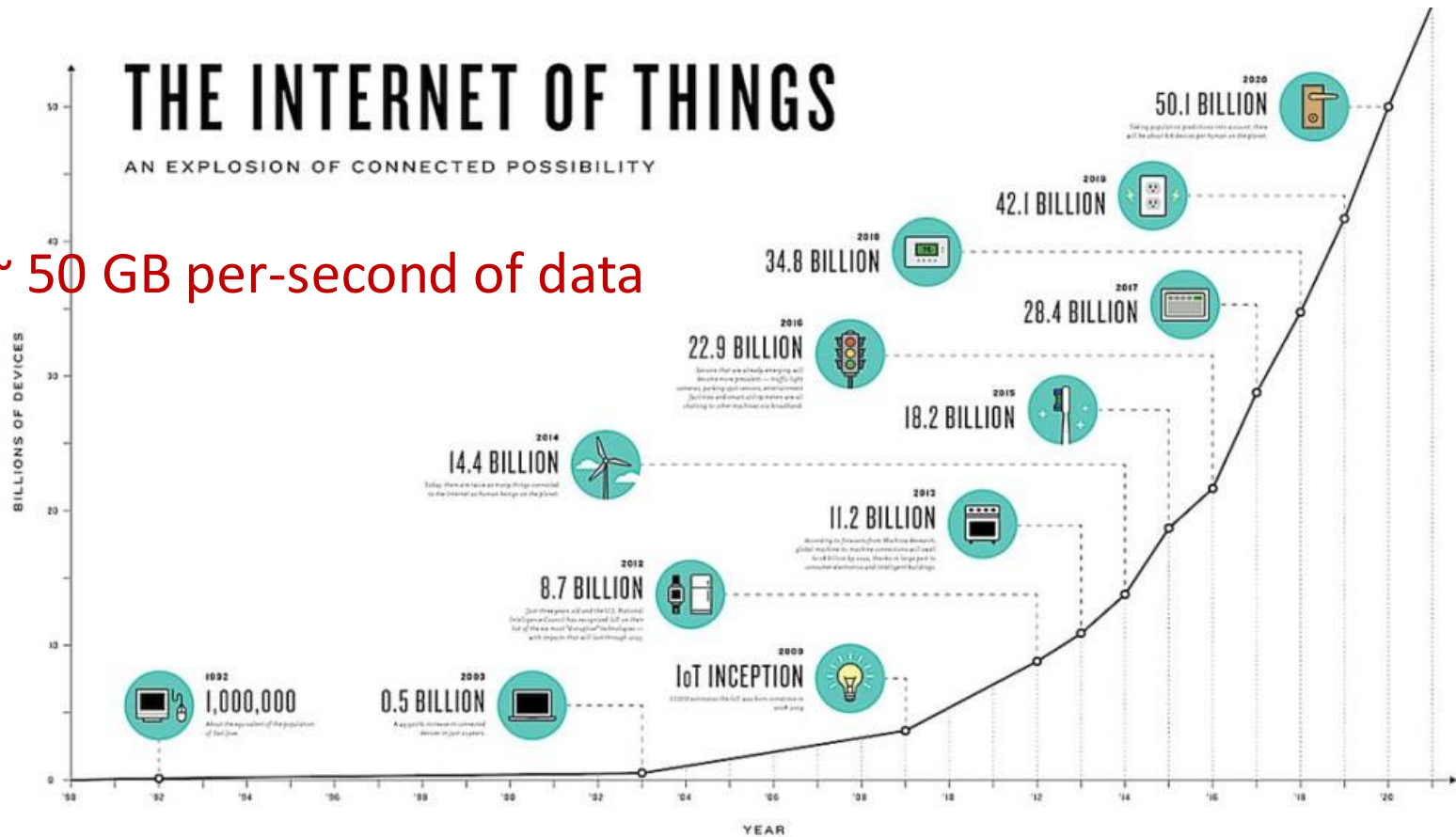
Network of physical objects that are connected to the internet allowing them to send, receive and exchange data

# Internet of Things



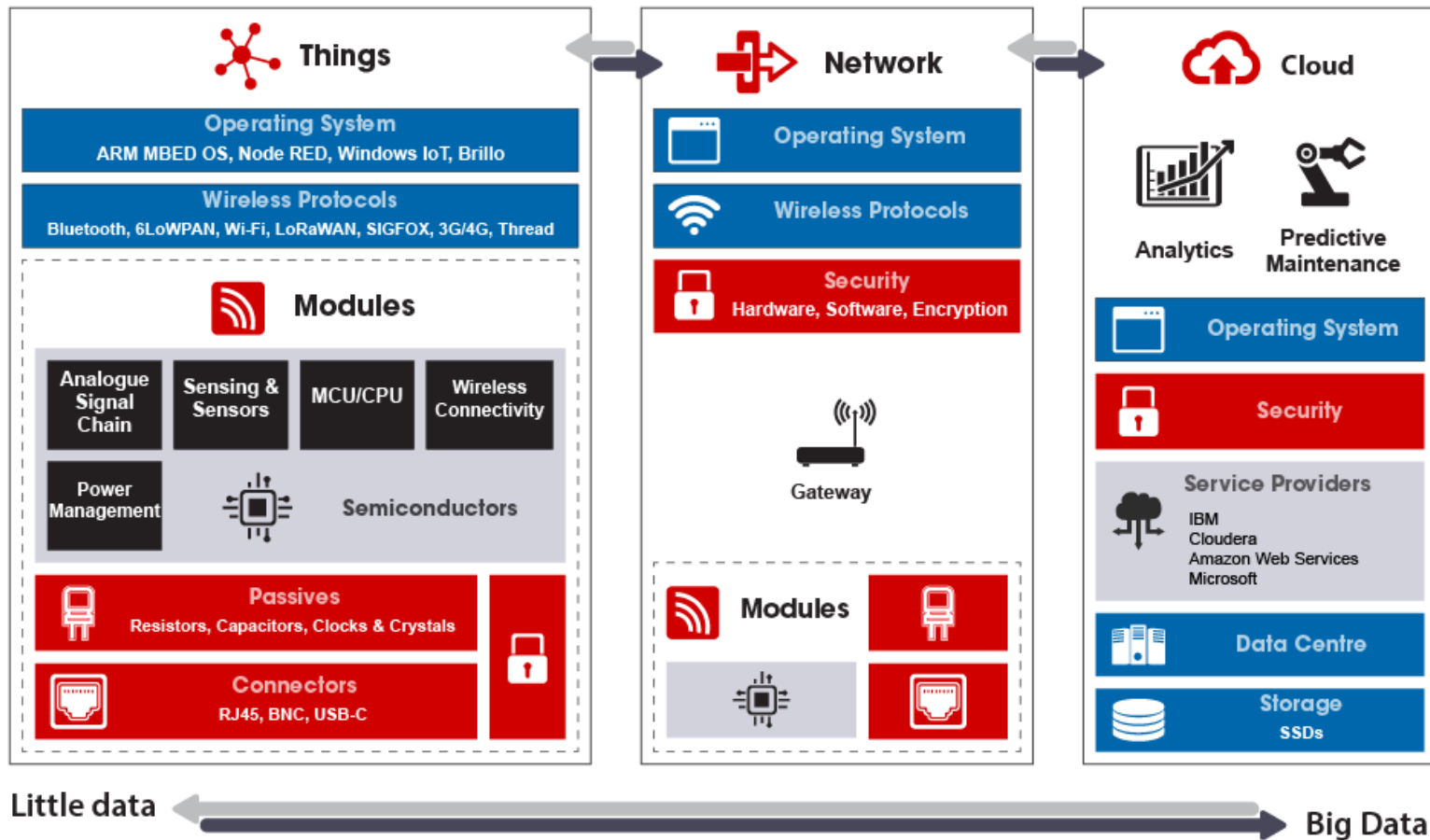
- Imagine a device push a byte per-second to the cloud

~ 50 GB per-second of data



# Internet of Things

# IoT Architecture



- A collection of files storing related data
- For example:
  - Facebook Post
  - Bank Account
  - UTeM Student's Records
  - Contact List on Cell Phone

Database

- A software that allows client to manage large database that stores, access, and manipulates data saved on disk, or even in RAM
- Organize data according to a specific pattern, called database model
- The DBMS has three core components:
  - Data storage engine
  - Query / Update engine
  - Schema management system

## Database Management Systems (DBMS)

- Data storage can be persistence or ephemeral
- The format of that data can vary widely: small or large files, organized by row, by column, or by content.

A/c number	First name	Last name	A/c Type	Branch
12345756453	Michael	Calder	Saving	Manhattan
12345978675	Nick	Brown	Current	Brooklyn

```
{  
  A/c number: 12345756453,  
  First name: "Michael",  
  Last name: "Calder",  
  A/c Type: "Saving",  
  Branch: "Manhattan"  
}
```

## Data Storage Engine

- Query Language are used for retrieving and storing data of different types.
  - SQL (Structured Query Language)
  - MQL (MongoDB Query Language)
- In order to expose those functions, the DBMS exposes APIs for client applications

Query / Update engine

- Define how you want your data to be structured
- Rigid schemas
  - useful when you know the exact specifications of each record in advance, and don't need to change often
- Flexible schemas
  - useful when you're working with unstructured data, or have constantly changing, variability in your data set, or need to respond to more rapidly changing requirements

Schema Management system

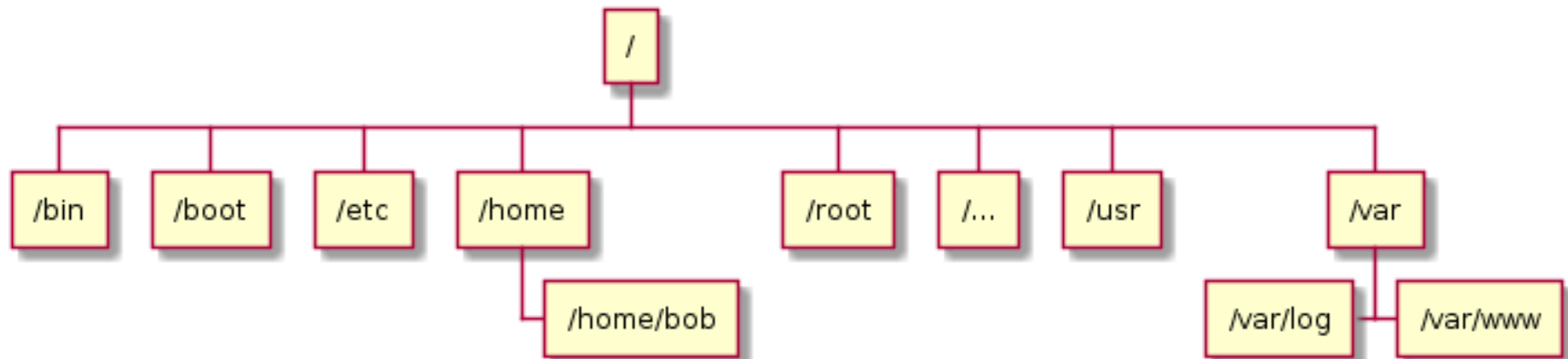
- Hierarchical databases
- Network databases
- Relational databases
- Non-relational databases
- Time series databases

## Types of Databases



- Hierarchical databases

- Encode a relationship between items where every record has a single parent.
- Tree-like structure that can be used to categorize records according to their parent record.



## Types of Databases



- Relational databases
  - Organize data using tables
  - Column has a name and a data type
  - Row represents a data item

A/c number	First name	Last name	A/c Type	Branch
12345756453	Michael	Calder	Saving	Manhattan
12345978675	Nick	Brown	Current	Brooklyn

## Types of Databases

- Non-relational databases
  - Also known as document-oriented databases
  - Use a key to uniquely identify data within the database
  - Do not prescribe any specific format or schema.

```
{  
  A/c number: 12345756453,  
  First name: "Michael",  
  Last name: "Calder",  
  A/c Type: "Saving",  
  Branch: "Manhattan"  
}
```

ID: breakfast

```
{  
  "type": "toast",  
  "bread": "whole wheat",  
  "spread": [  
    "butter",  
    "jam"  
  ]  
}
```

ID: lunch

```
{  
  "type": "salad",  
  "vegetarian": false,  
  "ingredients": [  
    "spinach",  
    "tomato",  
    "cucumber",  
    "carrot",  
    "dressing": [  
      "olive oil",  
      "vinegar",  
      "honey",  
      "lemon",  
      "salt",  
      "pepper",  
    ],  
    "tuna",  
    "walnuts"  
  ],  
  "rating": "5 stars",  
  "restaurant": "Skylight Diner"  
}
```

ID: dinner

```
{  
  "type": "pizza",  
  "size": "large",  
  "toppings": [  
    "pepperoni",  
    "tomato",  
    "sausage"  
  ],  
  "price": 9.00,  
  "presliced": true  
}
```

## Types of Databases

- Time series databases
  - Data stores that focus on collecting and managing values that change over time
  - Organized into structures that record the values for a single item over time or using timestamps as keys to store values for multiple metrics or columns at once.

Time	CPU Temp
2019-10-31T03:48:05+00:00	37
2019-10-31T03:48:10+00:00	42
2019-10-31T03:48:15+00:00	33
2019-10-31T03:48:20+00:00	34
2019-10-31T03:48:25+00:00	40
2019-10-31T03:48:30+00:00	42
2019-10-31T03:48:35+00:00	41

Time	CPU Temp	System Load	Memory Usage %
2019-10-31T03:48:05+00:00	37	0.85	92
2019-10-31T03:48:10+00:00	42	0.87	90
2019-10-31T03:48:15+00:00	33	0.74	87
2019-10-31T03:48:20+00:00	34	0.72	77
2019-10-31T03:48:25+00:00	40	0.88	81
2019-10-31T03:48:30+00:00	42	0.89	82
2019-10-31T03:48:35+00:00	41	0.88	82

## Types of Databases

- Also known as NoSQL Database
- Schema-less

Non-Relational Database

- Also known as NoSQL Database
- Schema-less

**string**

**number**

**string**

**string**

Name	Phone	Address	E-Mail
Soo	1234567890	FKEKK, UTeM	soo@utem.edu.my

Non-Relational Database

- Also known as NoSQL Database
- Schema-less

string

number

string

string

Name	Phone	Address	E-Mail
Soo	1234567890	FKEKK, UTeM	soo@utem.edu.my
Ali	<b>Mobile: 2344935809</b>	FKEKK, UTeM	ali@utem.edu.my

Non-Relational Database

- Also known as NoSQL Database
- **Schema-less**

```
{  
  name: Soo,  
  phone: 1234567890,  
  address: FKEKK, UTeM  
  email: soo@utem.edu.my  
}
```

```
{  
  name: Ali,  
  phone: {  
    mobile: 2344935809  
    home: 234439559  
  },  
  address: FKEKK, UTeM  
  email: ali@utem.edu.my  
}
```

# Non-Relational Database

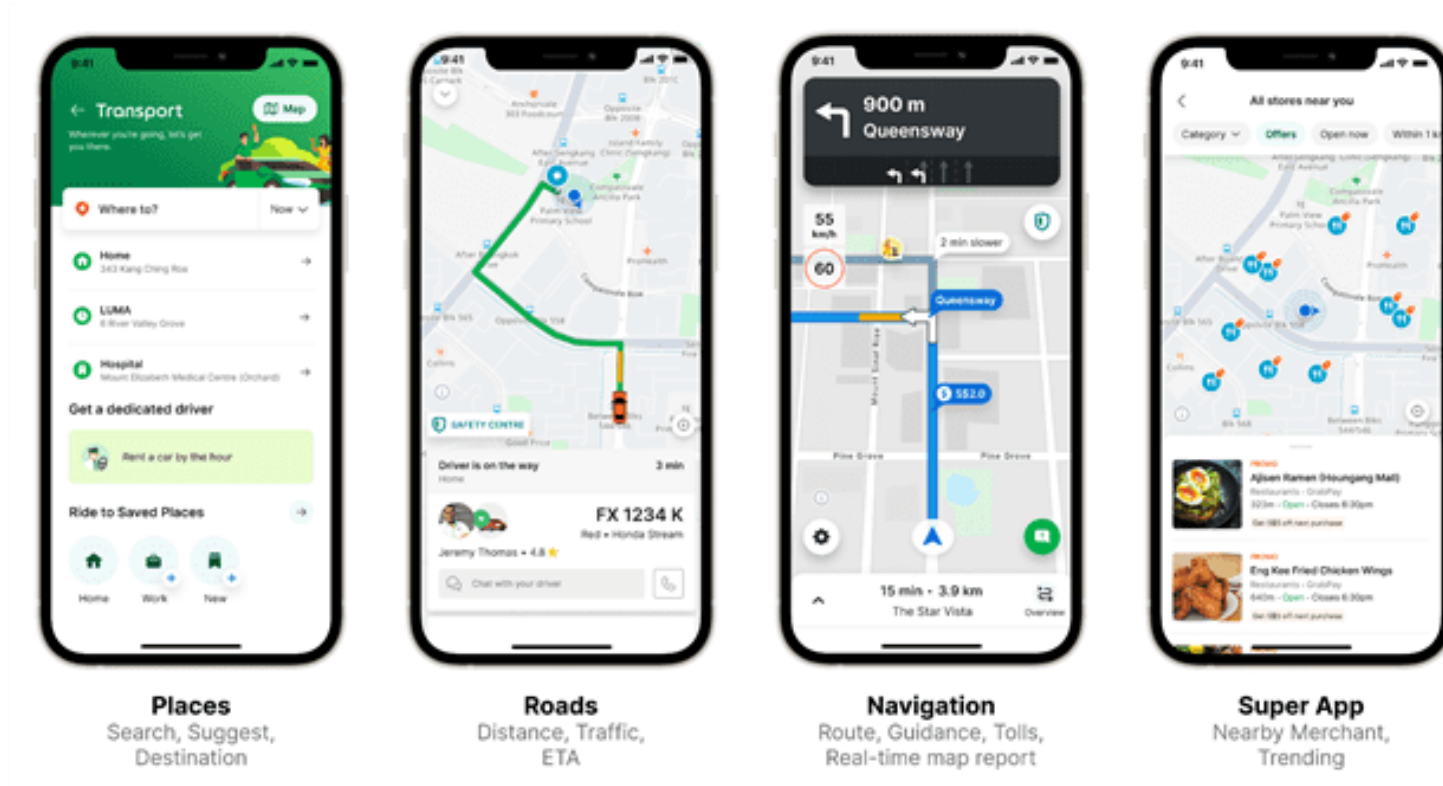


- Using key-value stores

Key	Value	
1234567890	KFC	<b>string</b>
3953833459	Pizzahut	<b>string</b>
2345938930	{ name: McDonalds country: MY }	<b>JSON</b>

Non-Relational Database

- Description of an information
- Example:



Non-Relational Database