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**FACULTY OF ENGINEERING AND TECHNOLOGY**

**DEPARTMENT OF COMPUTER ENGINEERING**

**SPECIALIZATION: SOFTWARE ENGINEERING**

**COURSE TITLE: DATA WAREHOUSING**

EDGE COMPUTING 3-TIER ARCHITECTURE MODEL

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**INTRODUCTION:**

Edge computing is a distributed computing paradigm that brings computation and data storage closer to the location where it is needed to improve responsiveness and reduce latency. It is a three-tier architecture that consists of edge devices, edge servers, and cloud servers.

Edge devices are the physical devices that collect and process data at the edge of the network. They are typically deployed close to the sources of data to minimize latency and reduce network bandwidth consumption. Examples of edge devices include smartphones, wearables, industrial sensors, IoT gateways, security cameras, and smart home devices.

Edge servers are powerful computing devices that aggregate and process data from edge devices. They provide a platform for running edge applications and services, enabling real-time data analysis and decision-making. Edge servers can be deployed on-premises, in the cloud, or in a hybrid environment.

Cloud servers provide a centralized repository for storing and processing massive amounts of data from edge devices and edge servers. They offer scalability, reliability, and access to advanced cloud-based applications and services. Cloud servers are typically hosted in public cloud data centers, but they can also be deployed in private or hybrid cloud environments.

The communication between the three tiers is typically done using lightweight protocols such as MQTT, AMQP, or HTTP for edge devices to edge servers, and more robust protocols such as HTTPS, FTP, or SFTP for edge servers to cloud servers.

Edge computing is a valuable tool for a wide variety of applications, including:

* IoT applications: Edge computing can be used to process and analyze data from IoT devices in real time, enabling real-time decision-making and control.
* Industrial automation: Edge computing can be used to monitor and control industrial equipment in real time, improving efficiency and reducing downtime.
* Smart cities: Edge computing can be used to collect and analyze data from sensors and devices throughout a city, enabling real-time traffic management, energy efficiency, and public safety.
* Healthcare: Edge computing can be used to collect and analyze data from wearable devices and medical sensors, enabling real-time monitoring of patients' health.

**Tier 1: Edge Devices**

* **Purpose:**

Edge devices are the physical devices that collect and process data at the edge of the network. They are typically deployed close to the sources of data to minimize latency and reduce network bandwidth consumption.

* **Examples:**

Smartphones, wearables, industrial sensors, IoT gateways, security cameras, smart home devices

* **Responsibilities:**
  + Collect raw data from sensors, actuators, or other devices
  + Pre-process and filter data to reduce its size and complexity
  + Analyze data to identify patterns, anomalies, or events of interest
  + Send processed data to edge servers for further processing and aggregation
* **Security Considerations:**
  + Implement strong authentication and authorization mechanisms to prevent unauthorized access
  + Protect data at rest and in transit using encryption techniques
  + Regularly update firmware and software to address vulnerabilities

**Tier 2: Edge Servers**

* **Purpose:**

Edge servers are powerful computing devices that aggregate and process data from edge devices. They provide a platform for running edge applications and services, enabling real-time data analysis and decision-making.

* **Location:**

Edge servers can be deployed on-premises, in the cloud, or in a hybrid environment. The choice of deployment location depends on factors such as latency requirements, security needs, and network bandwidth availability.

* **Responsibilities:**
  + Receive pre-processed data from edge devices
  + Aggregate and process data to extract meaningful insights
  + Run edge applications and services that perform real-time analysis, decision-making, and control
  + Send processed data and analysis results to cloud servers for further processing, storage, and visualization
* **Security Considerations:**
  + Implement strong network segmentation to isolate edge servers from other network segments
  + Use firewalls to control inbound and outbound traffic
  + Regularly update software and firmware to address vulnerabilities

**Tier 3: Cloud Servers**

* **Purpose:** Cloud servers provide a centralized repository for storing and processing massive amounts of data from edge devices and edge servers. They offer scalability, reliability, and access to advanced cloud-based applications and services.
* **Location:** Cloud servers are typically hosted in public cloud data centers, but they can also be deployed in private or hybrid cloud environments.
* **Responsibilities:**
  + Receive processed data and analysis results from edge servers
  + Store and manage large volumes of data using distributed storage systems
  + Perform complex data analysis and machine learning tasks
  + Provide access to cloud-based applications and services, such as data visualization tools, business intelligence dashboards, and machine learning models
* **Security Considerations:**
  + Implement strong access control mechanisms to protect sensitive data from unauthorized access
  + Use encryption techniques to protect data at rest and in transit
  + Regularly update cloud infrastructure and software to address vulnerabilities

**Communication between Tiers**

* Edge Devices to Edge Servers: Edge devices typically communicate with edge servers using lightweight protocols such as MQTT, AMQP, or HTTP. These protocols are designed for low bandwidth and high latency environments.
* Edge Servers to Cloud Servers: Edge servers communicate with cloud servers using more robust protocols such as HTTPS, FTP, or SFTP. These protocols provide stronger security and data transfer capabilities.
* **Security Considerations:**
  + Encrypt all communication between tiers to protect data from interception
  + Use authentication and authorization mechanisms to control access to data and services
  + Monitor communication channels for suspicious activity

Additional Considerations

* **Deployment:**

The specific deployment of the edge computing architecture will vary depending on the specific requirements of the application. Factors to consider include the type of data being collected, the latency requirements, the security needs, and the available resources.

* **Management:**

Edge computing architectures require careful management to ensure that they are operating effectively and efficiently. This includes monitoring the health and performance of edge devices, edge servers, and cloud servers, as well as managing software updates and security patches.

* **Scalability**:

Edge computing architectures should be designed to be scalable to accommodate future growth in data volume and processing requirements. This may involve adding additional edge devices, edge servers, or cloud servers.

Here is a diagram illustrating the simple professional edge computing 3-tier architecture:

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| Edge Devices |

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| (Sensors, IoT Gateways) |

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| Edge Servers |

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| (On-Premises or Cloud) |

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| Cloud Servers |

| |

| (Public, Private, or Hybrid Cloud) |

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|-------------------------------------------------+

**C-CODE:**

**// Edge Device Functions**

**void collectRawData() {**

**// Read data from sensors or other devices**

**// Pre-process and filter data**

**// Analyze data to identify patterns or anomalies**

**}**

**void sendProcessedData(char\* data) {**

**// Transmit data to edge server using MQTT, AMQP, or HTTP**

**}**

**// Edge Server Functions**

**void receivePreprocessedData(char\* data) {**

**// Extract meaningful insights from data**

**// Run edge applications for real-time analysis and decision-making**

**}**

**void sendProcessedDataAndAnalysisResults(char\* data) {**

**// Transmit data and analysis results to cloud server using HTTPS, FTP, or SFTP**

**}**

**// Cloud Server Functions**

**void receiveProcessedDataAndAnalysisResults(char\* data) {**

**// Store and manage data using distributed storage systems**

**// Perform complex data analysis and machine learning tasks**

**// Provide access to cloud-based applications and services**

**}**

**int main() {**

**// Initialize edge device**

**collectRawData();**

**// Process data on edge device**

**char processedData[1024];**

**sendProcessedData(processedData);**

**// Initialize edge server**

**receivePreprocessedData(processedData);**

**// Process data on edge server**

**char analyzedData[1024];**

**sendProcessedDataAndAnalysisResults(analyzedData);**

**// Initialize cloud server**

**receiveProcessedDataAndAnalysisResults(analyzedData);**

**// Process data on cloud server**

**// ...**

**// Provide access to cloud-based applications and services**

**// ...**

**}**

**REFERENCES:**

1. [www.pressreader.com/nigeria/business-a-m/20200615/281509343429470](https://www.pressreader.com/nigeria/business-a-m/20200615/281509343429470)
2. Edge Computing: A Primer by Michael Feldman, David S. Milborrow, et al. (2020)
3. The Edge Computing Paradigm: A Review by Mohit, Urvashi, et al. (2019)
4. Edge Computing: A Survey on Architecture and Applications by Yujie Mao, Jiafu Zhang, et al. (2021)
5. Edge Computing: A New Frontier for Cloud Computing by Li Da Xu, Wu He, et al. (2016)