

Real-Time Analytics in IIoT: Transforming Data Into Decisions

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(I)IoT in Modern Industry

IoT enables smarter operations by connecting physical devices and aligning with Industry 4.0 advancements. The convergence of IT and OT fosters automation and efficiency, delivering benefits like predictive maintenance, real-time decision-making, and improved operational performance. Applications span diverse industries, including manufacturing, logistics, oil & gas, utilities and smart cities.

Real-Time Data Processing

Why Real-Time Data Matters

- Downtime is expensive : Costs go up exponentially due to production deviations and stoppages.
- Overspending due to inefficient operations
- Timely insights are crucial in dynamic environments for real-time decisions and predicting failures. Industries deploy IoT devices to gain these insights
- Real-time data processing addresses scalability, interoperability, and data heterogeneity challenges.
- Businesses gain competitive advantages by acting on insights quickly.



IIoT – Real Time Analytics : Benefits

Utilizing zettabytes of IoT data



IoT devices produce very large volumes of data. Organizations are combining AI & ML algorithms with this vast amount of real time data to take proactive actions such as maintenance forecasting, operations optimization etc.

Real time analytics help in many aspects of industrial operations

- Operational uptime and accessibility
- Ensuring Quality
- Streamlining assembly line operation

IoT Architectures and Data Lifecycle

Understanding IoT System Layers

Sensing Layer:

Data collection via edge devices and sensors.

Communication Layer:

Efficient data transmission using multi-service protocols.

Analytics Layer:

Two Types of real-time analytics: Predictive & Prescriptive
Architectures: Cloud, edge-cloud hybrid

4 Stage IoT Architecture

Application Layer

Smart Applications and Management

Data Processing Layer

Processing Unit
Data Analytics/ Decision Unit

Network Layer

Internet Gateway/ Network Gateway
Network Technology

Sensing Layer

Physical Object
Sensor and Actuator

IIoT sensors in real time analytics

INDUSTRY 4.0

IIoT sensors play a critical role in generating real-time data for analytics.

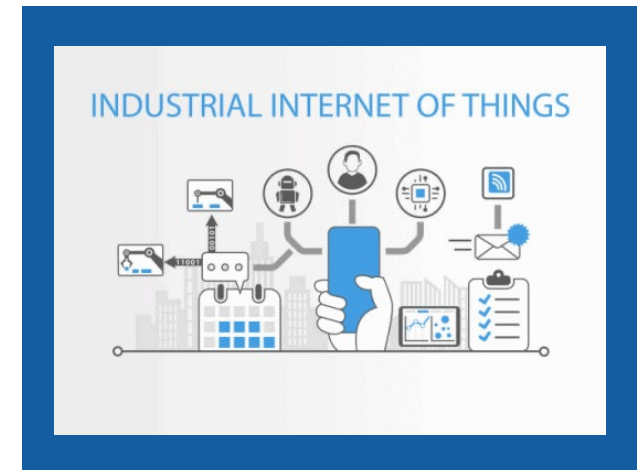
Common types of sensors employed

- Vibration sensors
- Temperature Sensors
- Pressure sensors
- Current & power consumption sensors

Communication for Real time analytics (RTA)

Network Requirements

- **Predictability:** Ensuring consistent and reliable packet delivery (drones, robots)
- **Latency:** Minimizing delay in packet transmission (Safety, electrical utilities)
- **Bandwidth:** Accommodating high data volumes (sensors, task offloading)
- **Wireless Communication:** Essential for mobile and wearable devices
- **Security :** ensure data confidentiality and detect unauthorized alterations
- **Time Synchronization :** shared understanding of time & reliable forwarding of timing messages



RTA requires real time networks



Real Time IIoT networks

Various Network Architectures can be envisioned Combining SDN, TSN, and edge computing to enhance reliability and determinism.

- **SDN:** Managing heterogeneous networks and prioritizing real-time tasks.
- **TSN:** Extending TSN capabilities and integrating with other systems like OPC UA.
- **Real-Time Aware Wireless Technologies:** Adapting TSN methods for wireless communication and developing real-time WiFi solutions.
- **5G:** Implementing private 5G networks and network slicing for industrial applications.
- **Device-Layer Technologies:** Enhancing real-time capabilities at the hardware level, including priority-aware packet processing and MAC layer filtering.

IIoT System Architectures

Optimized Architectures for real-time analytics



Cloud-based:

- 👍 Centralized data aggregation and analysis for high computational power
- 👎 high latency, bandwidth limitations, and unstable connections



Edge-Cloud Collaborative:

- 👍 Distributed processing for latency and bandwidth reduction
- 👍 Optimizes task allocation for real-time requirements



Digital Twin Integration:

- 👍 Virtual replicas of physical system continuously updated with real-time data
- 👍 Combined with simulations for decision support

AI Techniques in Real Time analytics

Machine Learning Approaches

- **Supervised Learning:**
 - Used for failure prediction and severity classification.
 - Algorithms like Support Vector Machines (SVMs) and Decision Trees classify operational states and detect anomalies.
- **Unsupervised Learning:**
 - Useful for anomaly detection in systems with limited failure data
 - Techniques like k-Means clustering and Principal Component Analysis (PCA) identify patterns and deviations without predefined labels.

Deep Learning Techniques

- **Convolutional Neural Networks (CNNs):**
 - For analyzing sensor data, including vibration and acoustic signatures.
 - Automatically extract features for anomaly detection and classification.
- **Recurrent Neural Networks (RNNs):**
 - Specialized Long Short-Term Memory (LSTM) networks capture temporal dependencies in sensor data.
 - Used for predicting Remaining Useful Life (RUL) and monitoring degradation trends.
- **Hybrid Models:**
 - Combining CNNs and LSTMs enhances both feature extraction and time-series analysis for more accurate predictions.

IoT Applications in Action

IoT Applications Across Industries



Smart Systems:

Healthcare, energy grids,
environmental monitoring.

Industrial IoT:

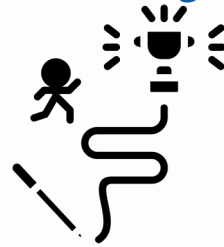
Predictive maintenance, worker
safety, autonomous vehicles.

Digital Twins:

Optimizing production and
supply chains.

Challenges in IoT Data Processing

Overcoming IoT Data Challenges



Overcoming IoT data challenges involves managing vast, diverse datasets characterized by high volume, velocity, and variety. Networking demands require advancements like time-sensitive networking (TSN) and 5G to ensure seamless connectivity. Additionally, addressing standardization gaps in protocols and platforms is crucial for achieving interoperability and streamlining IoT system integration.

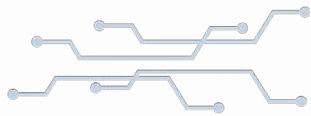
SECURITY IN IOT

Ensuring IoT Security and Compliance

The growing threats to connected devices necessitate robust encryption and authentication protocols to safeguard sensitive data and ensure secure communications. Simultaneously, adherence to regulatory frameworks such as GDPR and ISO 27001 is essential for building trust, maintaining compliance, and protecting user privacy in IoT ecosystems.

Future Trends in IoT

The Future of IoT and Real-Time Analytics



Emerging tech:

5G, digital twins, and quantum computing.



Enhanced edge-cloud collaboration frameworks.



Privacy and real-time security advancements powered by AI.

Conclusion

The Road Ahead for IIoT

- **Key Takeaways: Real-time analytics transforms industries with actionable insights.**
 - **Collaboration between stakeholders drives innovation.**
- **Future Outlook: Emphasis on flexibility and tech adoption for sustained growth.**

THANK YOU!

