

PTP in Industrial and Medical Applications

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Agenda

1. Introduction to PTP
2. PTP in Industrial Automation
3. PTP in Smart Grids
4. PTP in Railways
5. PTP in Medical Devices

Introduction to PTP

Overview of Precision Time Protocol



Accuracy

PTP is an IEEE 1588 standard protocol offering sub-microsecond clock synchronization accuracy.

Master-Slave Communication

PTP synchronizes clocks by exchanging timing messages between master and slave devices in the network.

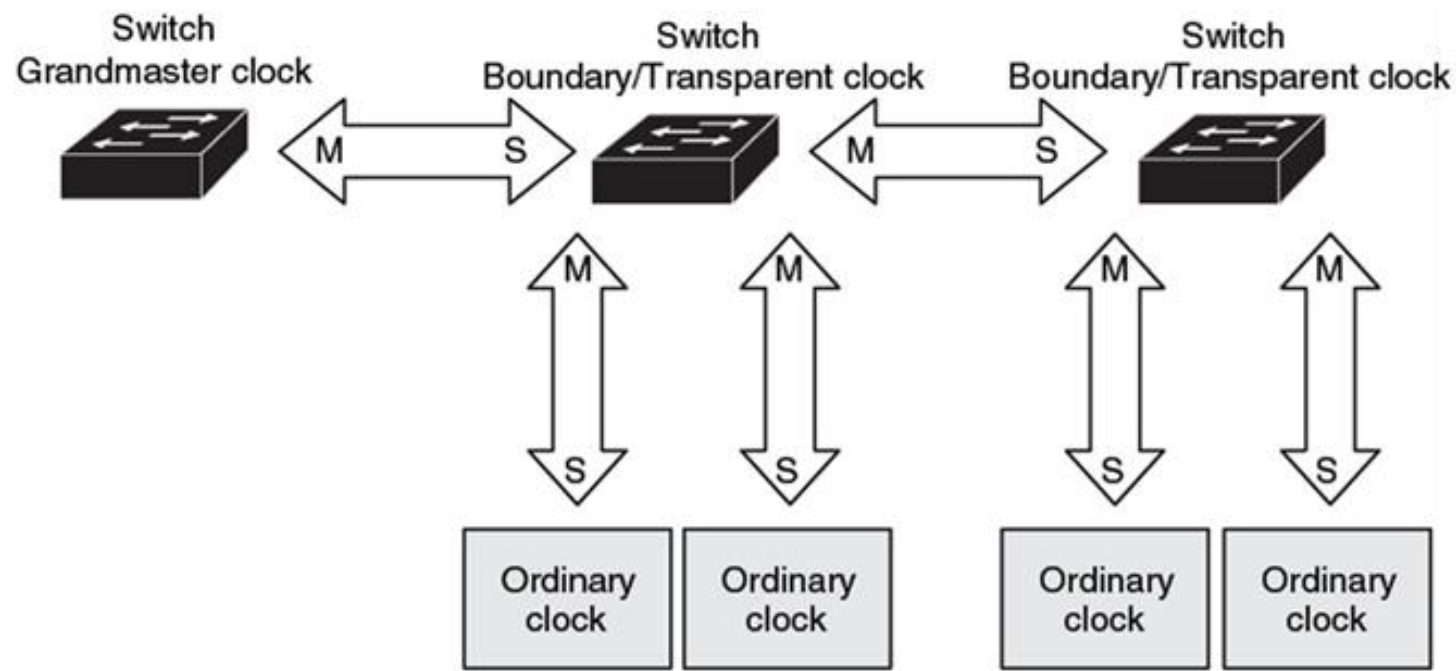
Application Environment

PTP is essential for time-sensitive fields like industrial automation, telecommunications, and power systems.

Delay Compensation

PTP compensates for network delays and jitter for robust timing.

PTP Clock Hierarchy



Grandmaster Clock

The primary and most accurate time source in the hierarchy, acting as the primary clock source for all downstream clocks.

Boundary / Transparent Clock

A network device that acts as a secondary clock to an upstream primary clock and as a primary clock source to downstream secondary clocks, relaying and potentially correcting time information.

Ordinary Clock

An end-device clock that acts usually as a slave, synchronizing its time to an upstream primary clock.

Features	IEEE 1588v2	IEEE 802.1AS (gPTP)
Boundary Clock	✔ Supported	✘ Not supported
Transparent Clock /P2P	✔ Supported	✔ Used exclusively
Typical Use Case	Industrial, Telecom, Power Grid	Audio Video Bridging, Time Sensitive Networking, Automotive Ethernet

PTP in Industrial Automation

Applications in Automation Systems

Synchronization in Automation

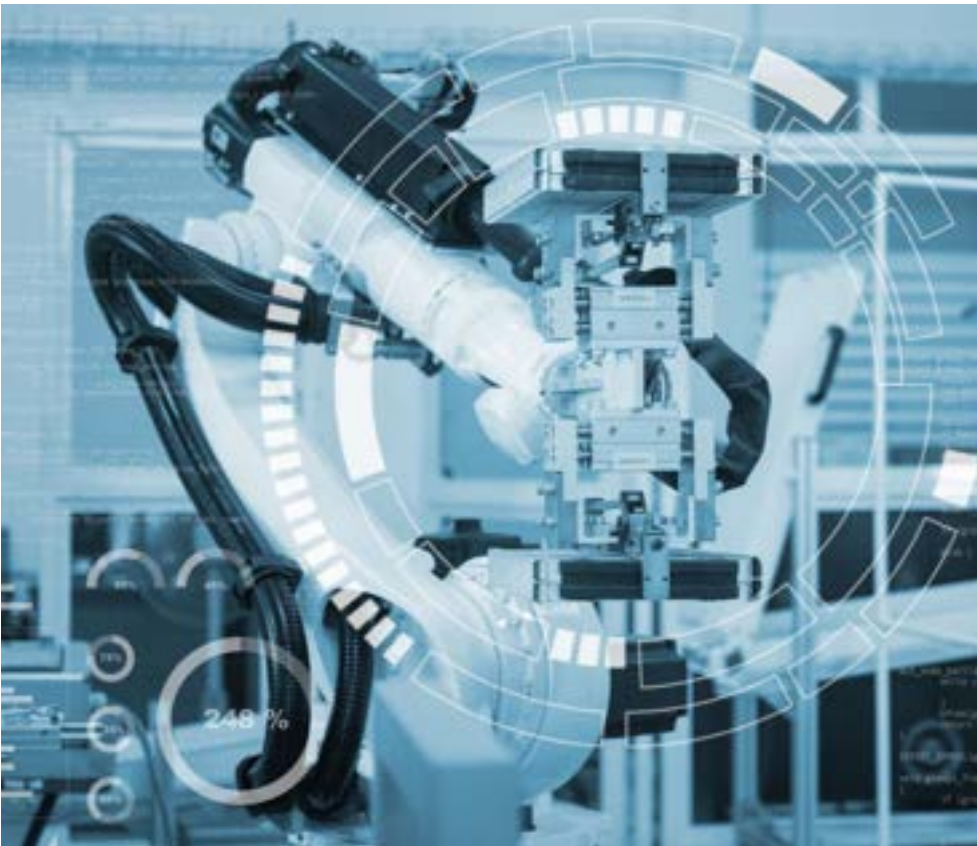
PTP synchronizes distributed control systems, sensors, and actuators for coordinated operation.

Improved Manufacturing Efficiency

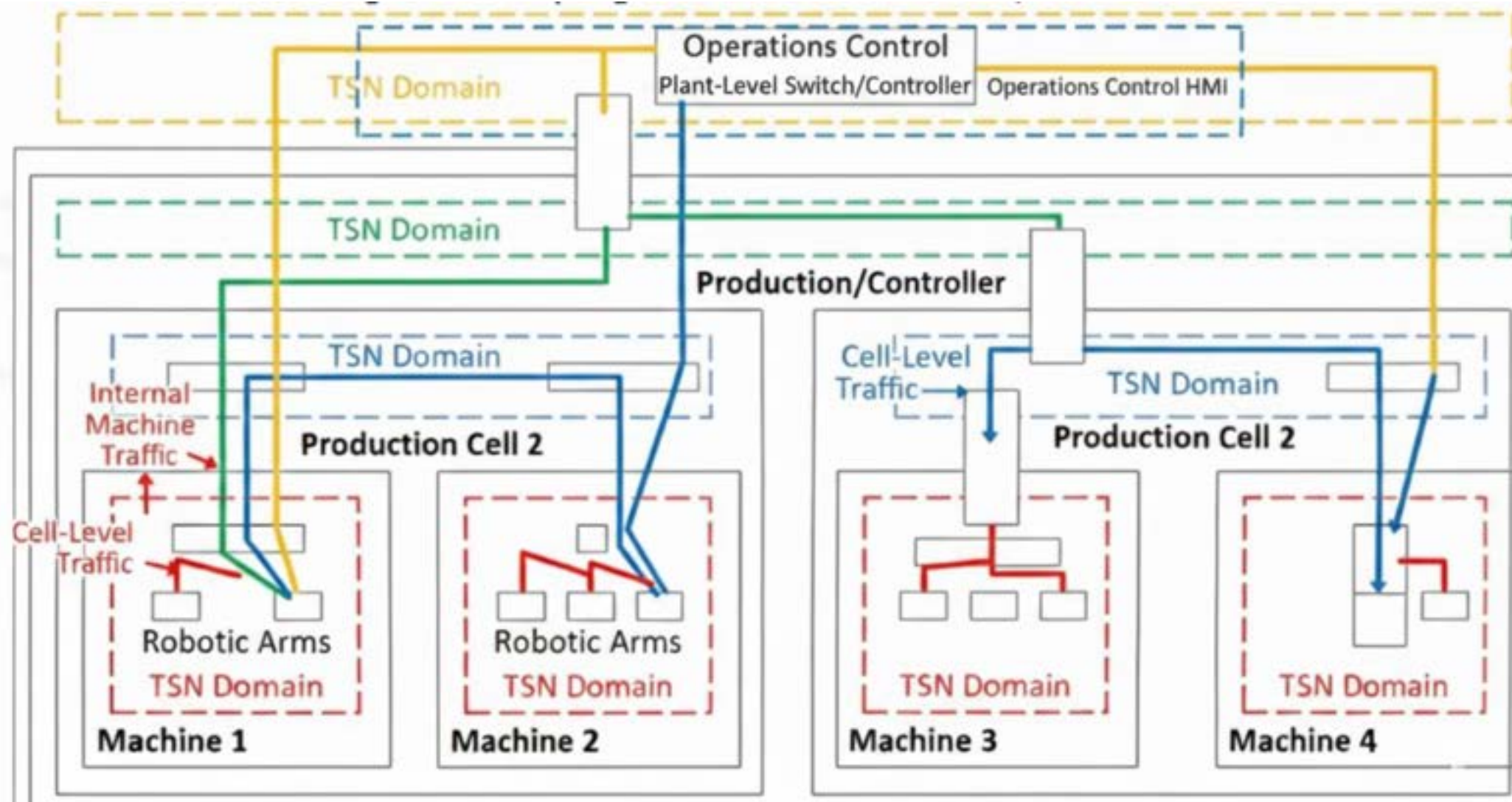
Robotic arms operate in sync to reduce cycle times and improve product quality.

Accurate Real-Time Analytics

PTP ensures precise timestamping of sensor data for better decision-making.



Industrial Automation Flows



Industrial Automation Flows (Continued)

Factory Automation

- Real time control.
- Sync accuracy requirements: **250 μ s to 1 ms.**
- Reduces latency and jitter, improving the accuracy and efficiency of operations.

Motion Control Systems

- Coordinated control of multi-axis machines.
- Sync accuracy requirements: **250 μ s to 500 μ s.**
- Allows deterministic data delivery, crucial for maintaining motion profiles and avoiding mechanical errors.

Automotive Manufacturing

- Sync accuracy requirements: **1 ms to 10 ms.**
- Enables interoperability between devices from different vendors using standardized Ethernet.

PTP in Smart Grids



Role in Smart Grid Synchronization

Accurate Time Synchronization

Precise timing enables PMUs to capture accurate voltage and current waveforms for real-time grid analysis and fault detection.

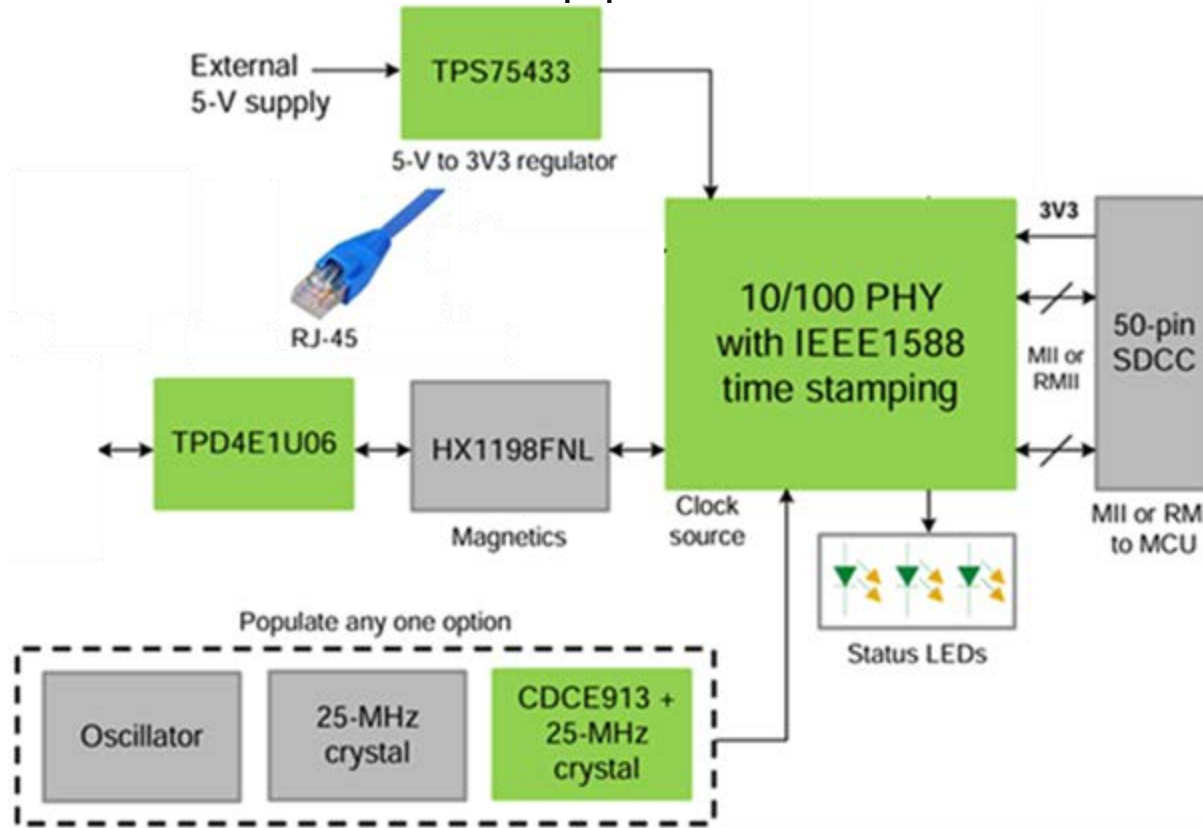
Reliable GPS Alternative

PTP provides accurate synchronization comparable to GPS without satellite vulnerabilities, ensuring stable grid operations.

Supports Renewable Integration

PTP synchronizes data collection and control across renewable energy units, enhancing grid resilience and efficiency.

Example of Ethernet Solution Using PTP Transceiver for Grid Infrastructure Applications



Approaches for synchronizing control devices

- Dedicated timing systems that use stand-alone cabling and repeaters which is traditionally ineffective.
- Networked timing systems that use Ethernet networking cables and switches shared with other automation applications and use PTP.

Ultra-Precise Time Synchronization

- Fault detection and isolation in nanoseconds range.
- Event correlation across substations.
- Coordinated switching and protection.

Enhancing Grid Automation

- Faster and accurate responses to grid events.
- Improved reliability and service quality.
- Reduced downtime and maintenance costs.

PTP in Railways



Modern Traction Power Systems

Evolution of TPS

Traction power systems evolved from conventional to smart systems requiring precise synchronization.

Role of Precision Time Protocol

PTP enables precise time synchronization for coordinated monitoring and control of power flows.

Benefits of Synchronization

Synchronized data improves efficiency, fault detection, regenerative braking, and power quality management.

DTG vs CBTC

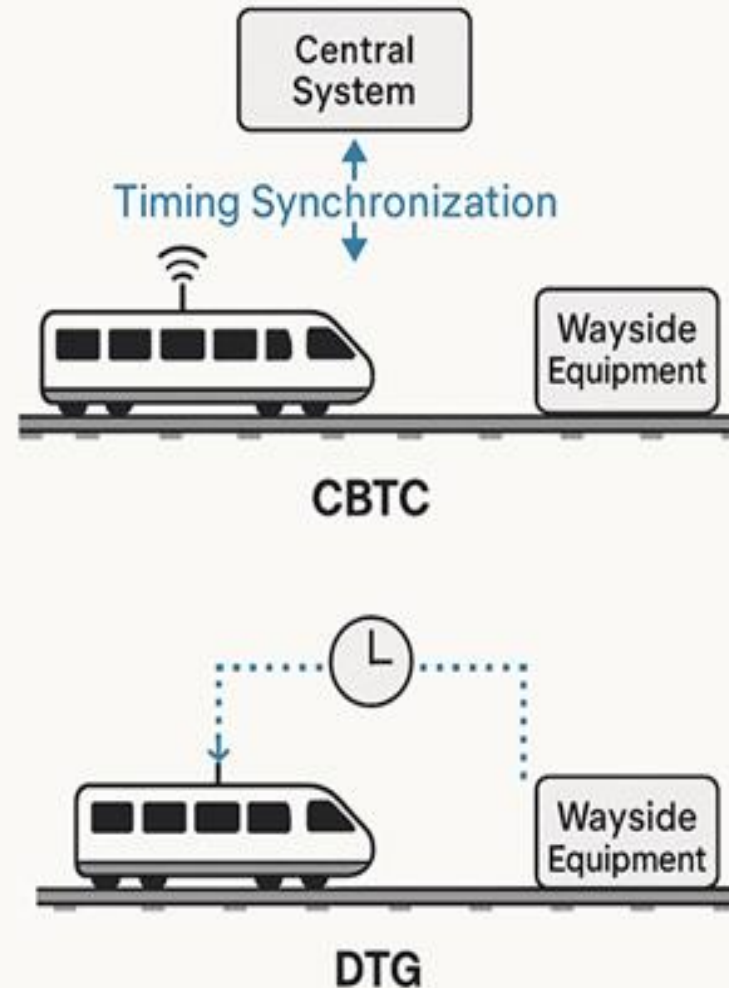
Precise Timing Protocol

DTG

- Intermittent updates
- Basic clock systems
- Timing accuracy in seconds

CBTC

- Continuous updates
- IEEE 1588 PTP
- Timing accuracy in sub-milliseconds



An Example of Metro Rail Systems

GM Clock in Central Control system

It acts as primary source clock for CBTC network. It distributes precise time to all nodes like onboard train equipment and wayside controllers.

Boundary Clock in Managed Ethernet Switches

Serve as boundary clocks to propagate precise timing across the network and often close to depot systems.

Slave Clock in On-board train Equipment

Onboard Train Equipment includes Train Control and Monitoring System (TCMS), Automatic Train Protection (ATP) and Automatic Train Operation (ATO).

PTP in Medical Devices

Enhancing Medical Monitoring and Diagnostics

Synchronized Patient Monitoring

PTP ensures accurate timestamps for real-time vital signs monitoring and timely medical interventions.

Enhanced Imaging Precision

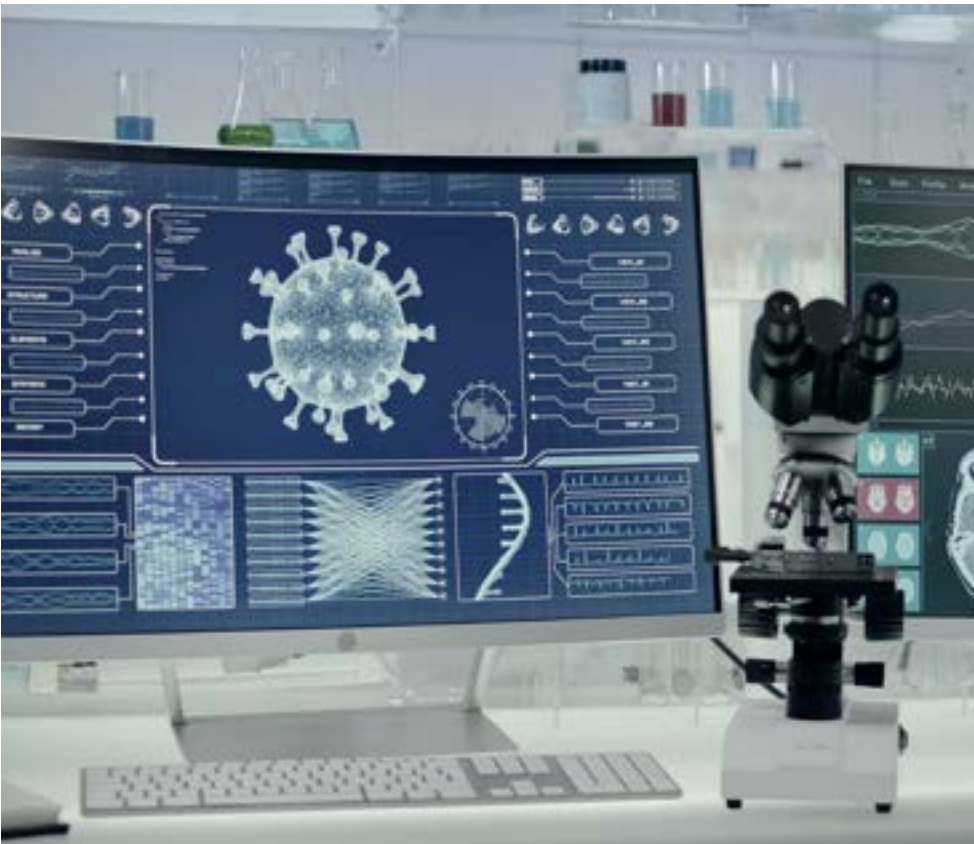
Precise timing from PTP improves image resolution and consistency in diagnostic equipment.

Internet of Medical Things Integration

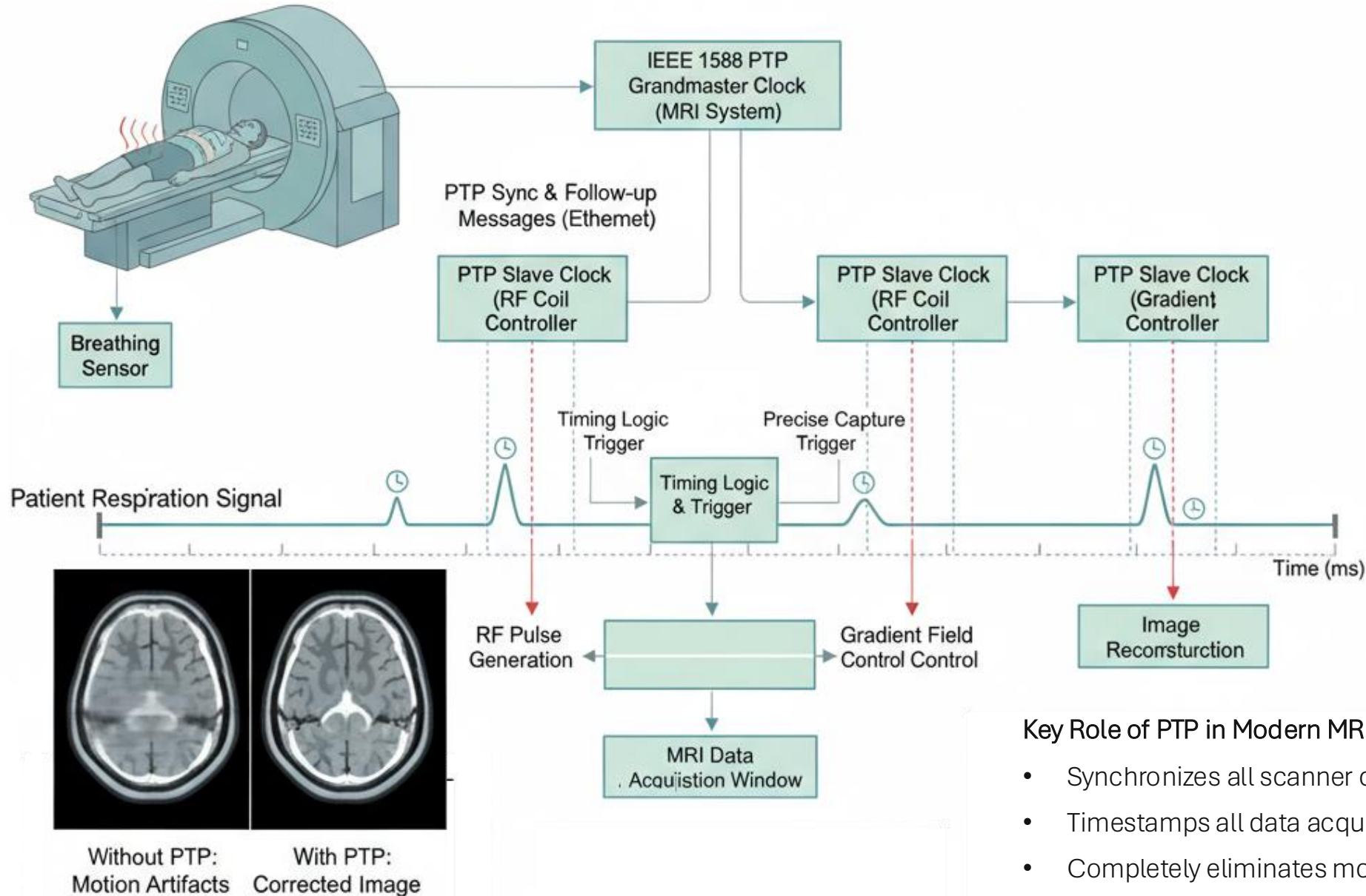
PTP enables synchronized data exchange among interconnected medical devices in IoMT systems.

Secure Low-Power Solutions

Developments focus on secure and energy-efficient PTP implementations for patient safety and data integrity.



Improving MRI Workflows with Real Time Image Acquisition



Real-time MR Image-guided Surgical Robotic System



1. Real-Time MR Imaging
2. Instrument Tracking
3. Image-to-Robot Registration
4. Timing Synchronization

Thank You!