LOW-COST RS485 MODBUS-BASED MODULAR I/O SYSTEM FOR MSME INDUSTRIAL AUTOMATION

INDUSTRY INNOVATION TRACK 8

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PROBLEM STATEMENT

1 *HIGH COST OF AUTOMATION FOR MSMES*

- PLC I/O modules are very expensive (₹4,000–₹20,000)
- MSMEs cannot scale automation due to high module cost

2 *VENDOR LOCK-IN*

- I/O modules only work with same-brand PLCs
- Forces MSMEs to buy costly proprietary add-ons

3 *LACK OF MODULAR I/O*

- MSMEs need small combinations (2AI / 4DI / 2DO)
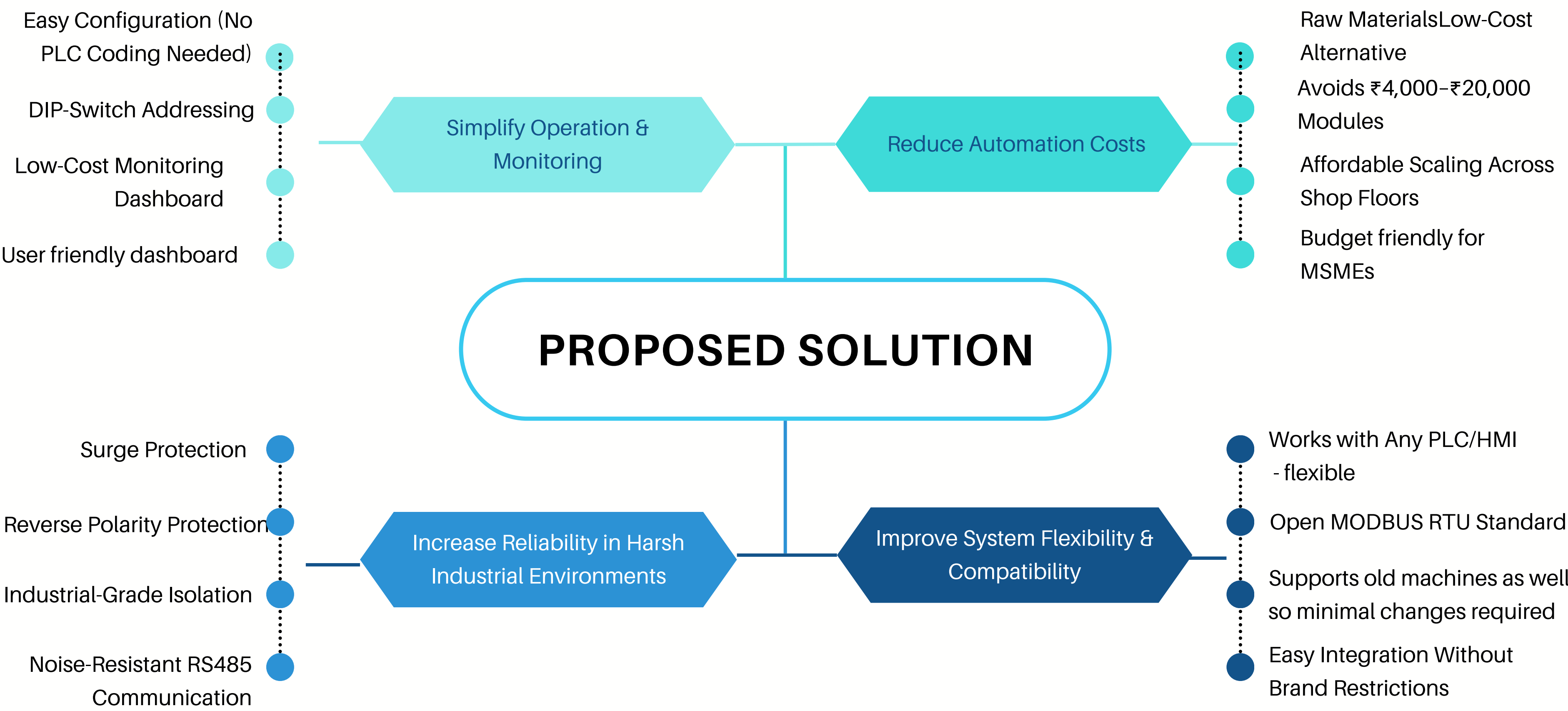- Existing modules are large, fixed, and overpriced

4 *LEGACY MACHINE COMPATIBILITY*

- Many MSMEs use old relay-based machines
- Existing controllers don't support RS485 MODBUS
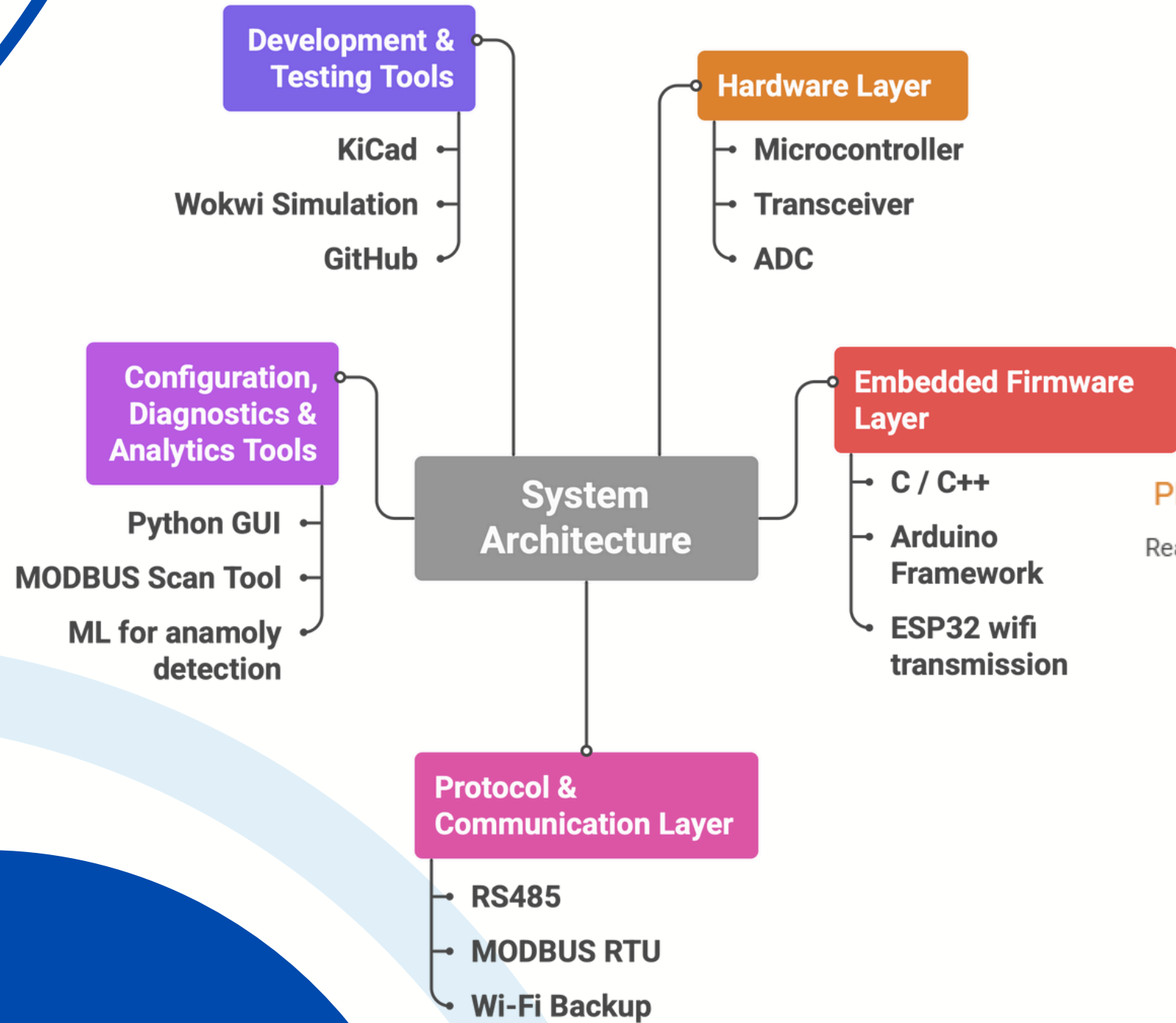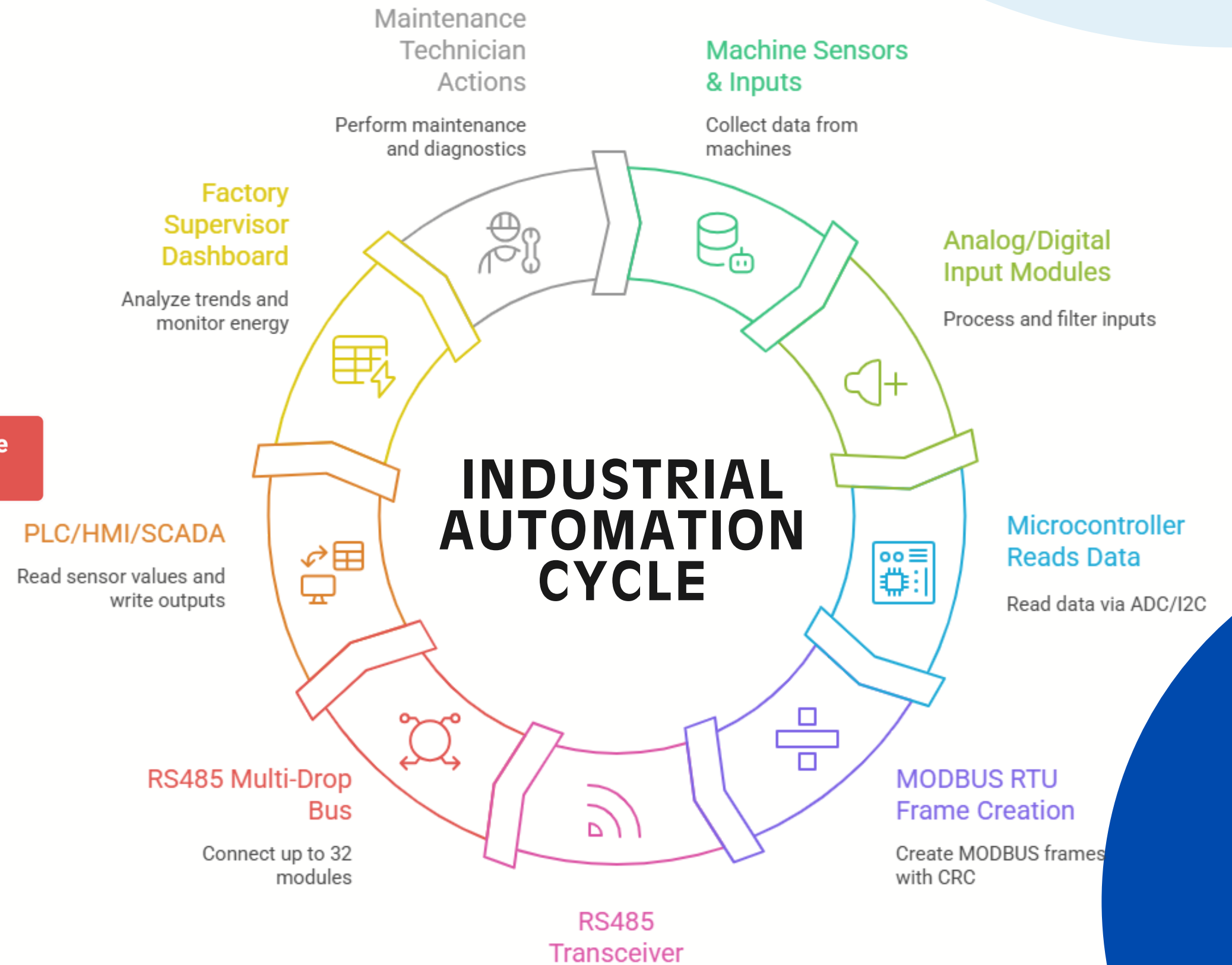- No easy way to retrofit sensors/I/

5 *POOR ELECTRICAL PROTECTION*

- Cheap controllers lack surge/ESD protection
- Frequent failures due to motor noise & welding spikes
- No isolation or reverse polarity safety

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PROPOSED SOLUTION

Simplify Operation & Monitoring
- Easy Configuration (No PLC Coding Needed)
- DIP-Switch Addressing
- Low-Cost Monitoring Dashboard
- User friendly dashboard

Reduce Automation Costs
- Raw MaterialsLow-Cost Alternative
- Avoids ₹4,000–₹20,000 Modules
- Affordable Scaling Across Shop Floors
- Budget friendly for MSMEs

Increase Reliability in Harsh Industrial Environments
- Surge Protection
- Reverse Polarity Protection
- Industrial-Grade Isolation
- Noise-Resistant RS485 Communication

Improve System Flexibility & Compatibility
- Works with Any PLC/HMI - flexible
- Open MODBUS RTU Standard
- Supports old machines as well so minimal changes required
- Easy Integration Without Brand Restrictions

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System Architecture for Connected Vehicles

Development & Testing Tools
- KiCad
- Wokwi Simulation
- GitHub

Hardware Layer
- Microcontroller
- Transceiver
- ADC

Configuration, Diagnostics & Analytics Tools
- Python GUI
- MODBUS Scan Tool
- ML for anamoly detection

System Architecture

Embedded Firmware Layer
- C / C++
- Arduino Framework
- ESP32 wifi transmission

Protocol & Communication Layer
- RS485
- MODBUS RTU
- Wi-Fi Backup

Industrial Automation Cycle

Maintenance Technician Actions
Perform maintenance and diagnostics

Machine Sensors & Inputs
Collect data from machines

Analog/Digital Input Modules
Process and filter inputs

Factory Supervisor Dashboard
Analyze trends and monitor energy

Microcontroller Reads Data
Read data via ADC/I2C

PLC/HMI/SCADA
Read sensor values and write outputs

MODBUS RTU Frame Creation
Create MODBUS frames with CRC

RS485 Multi-Drop Bus
Connect up to 32 modules

RS485 Transceiver

INDUSTRIAL AUTOMATION CYCLE

Made with Napkin

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COST ANALYSIS

FEATURE	EXISTING MARKET	PROPOSED SOLUTION
Hardware Type	PLC I/O Modules (Siemens, Mitsubishi, Wago, Delta, Omron)	Low-Cost Modular RS485 MODBUS I/O System
Price Range (per module)	4,000 – ₹20,000	₹700 – ₹1,200 (prototype) / ₹480 – ₹850 (mass production)
Module Size	Large, fixed multi-channel units	Compact, customizable (AI / DI / DO mix)
Monitoring Layer	SCADA/HMI extremely expensive	Optional low-cost dashboard available
Maintenance Cost	High — branded components costly to replace	Very low — generic and easy to service

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CONCLUSION

70-90% Cheaper Than PLC I/O ModulesReliability

1

By using ESP32/ESP8266 and MAX485 modules, our system delivers reliable industrial I/O at a fraction of PLC costs — making automation affordable for MSMEs.

Open, Vendor-Independent MODBUS RTU Architecture

2

Works with any PLC, HMI, SCADA, or industrial controller. No vendor lock-in — completely interoperable using standard MODBUS RTU over RS485.

Modular I/O Nodes for Maximum Flexibility

3

Each node (AI/DI/DO) is an independent ESP-based module. MSMEs can add or remove nodes as needed without redesigning the system.

Robust, Industrial-Ready Reliability

4

Nodes include isolation (via MAX485), reverse polarity protection, surge suppression, watchdog timer, and noise-resistant RS485 communication — suitable for factory floors.

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