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Decentralized Intelligence in EMBEDDED SYSTEMS USING EDGE AI

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From Automation to Intelligence

How AI Is Quietly Redefining Everyday Work

GAMIFICATION IN RECRUITMENT A Modern Approach to Student

CONTRIBUTORS

About Us

Our journey began in 2008 with the establishment of our first office in Kochi, where our operations team initiated industrial automation projects. Just a year later, we launched our first training center in Calicut. With an unwavering commitment to quality, we quickly gained the trust of students not only across India but also from countries in Africa.

Over time, our presence expanded into Nigeria, Qatar, the UAE, Kenya, and the Kingdom of Saudi Arabia. By 2025 IPCS global Operates 33+ Centres worldwide, earning a reputation as one of the most trusted and respected providers of core technical training—offering programs designed to be truly future-ready.

Each of our programs is carefully crafted to align with global industry trends, employment opportunities, and evolving market needs. Our current offerings include:

- Industrial Automation
- Building Automation Technology
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- Embedded & IoT
- Python & Data Science
- Artificial Intelligence
- Software Testing

Key highlights of our training include:

- 100% live and interactive sessions
- Government and internationally recognized certifications
- Comprehensive placement support

Looking ahead, we are on track to expand our network to 50 centers by 2025, reflecting our vision for growth and commitment to excellence. We welcome passionate entrepreneurs and visionary investors to join us—whether as franchisees under our proven model or as strategic partners driving our global expansion. Together, we can build opportunities, shape careers, and create lasting impact in communities around the world.

At IPCS, our mission is to equip students with the skills of tomorrow by staying aligned with emerging technologies, while upholding the highest ethical standards. We cultivate a culture of teamwork, professionalism, and mutual respect, ensuring student success and client satisfaction across all domains.

In today's digital age, technology is the backbone of growth and innovation. Embracing this reality, we continue to deliver excellence across the globe.

To further our vision, Team IPCS proudly presents Iziar—a magazine dedicated to exploring technological insights, industry trends, startups, and digital culture. Iziar aims to make **technology accessible, engaging, and inspiring, keeping readers informed about the innovations shaping our future.**

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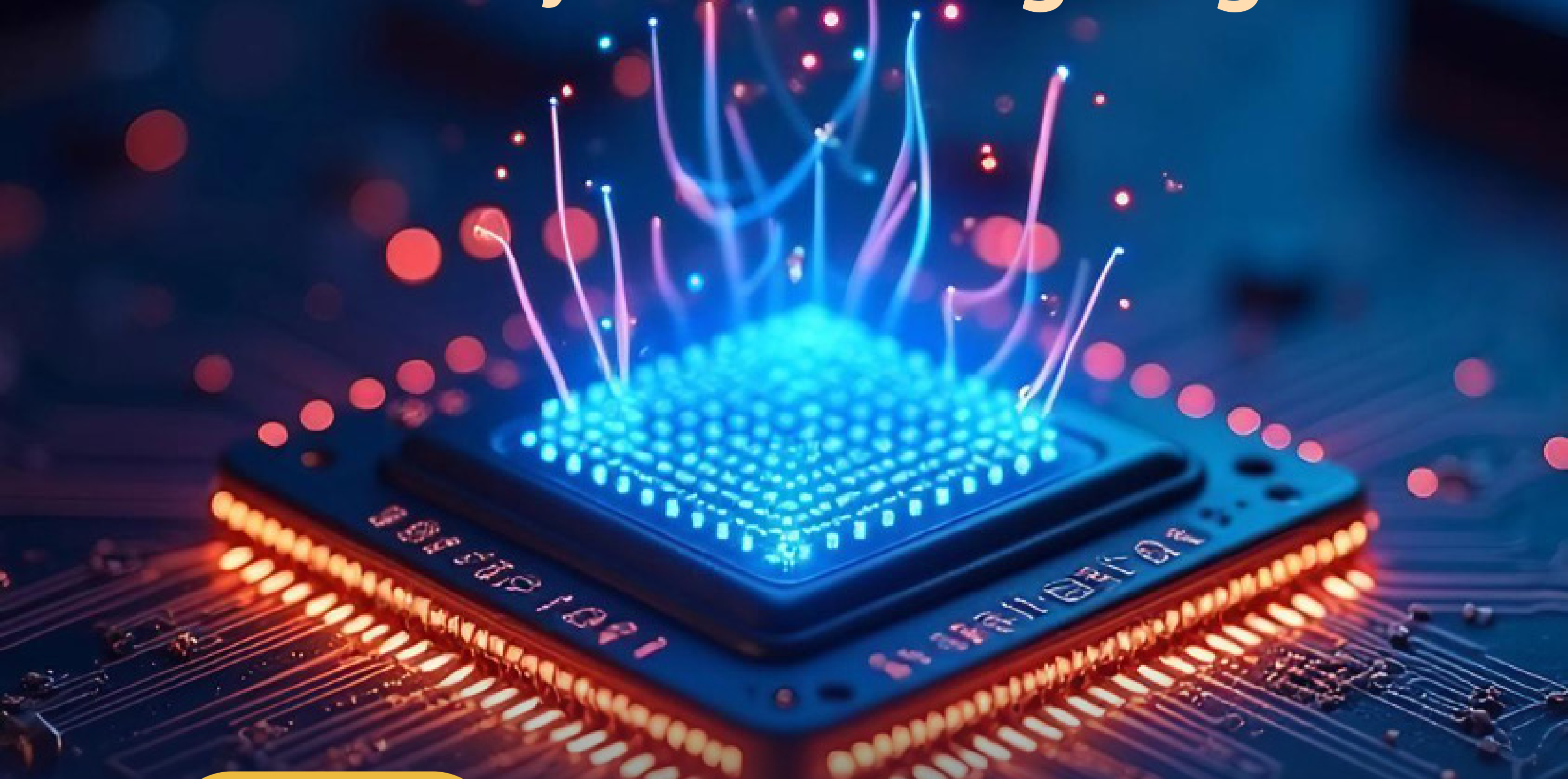
Decentralized Intelligence in Embedded Systems Using Edge AI



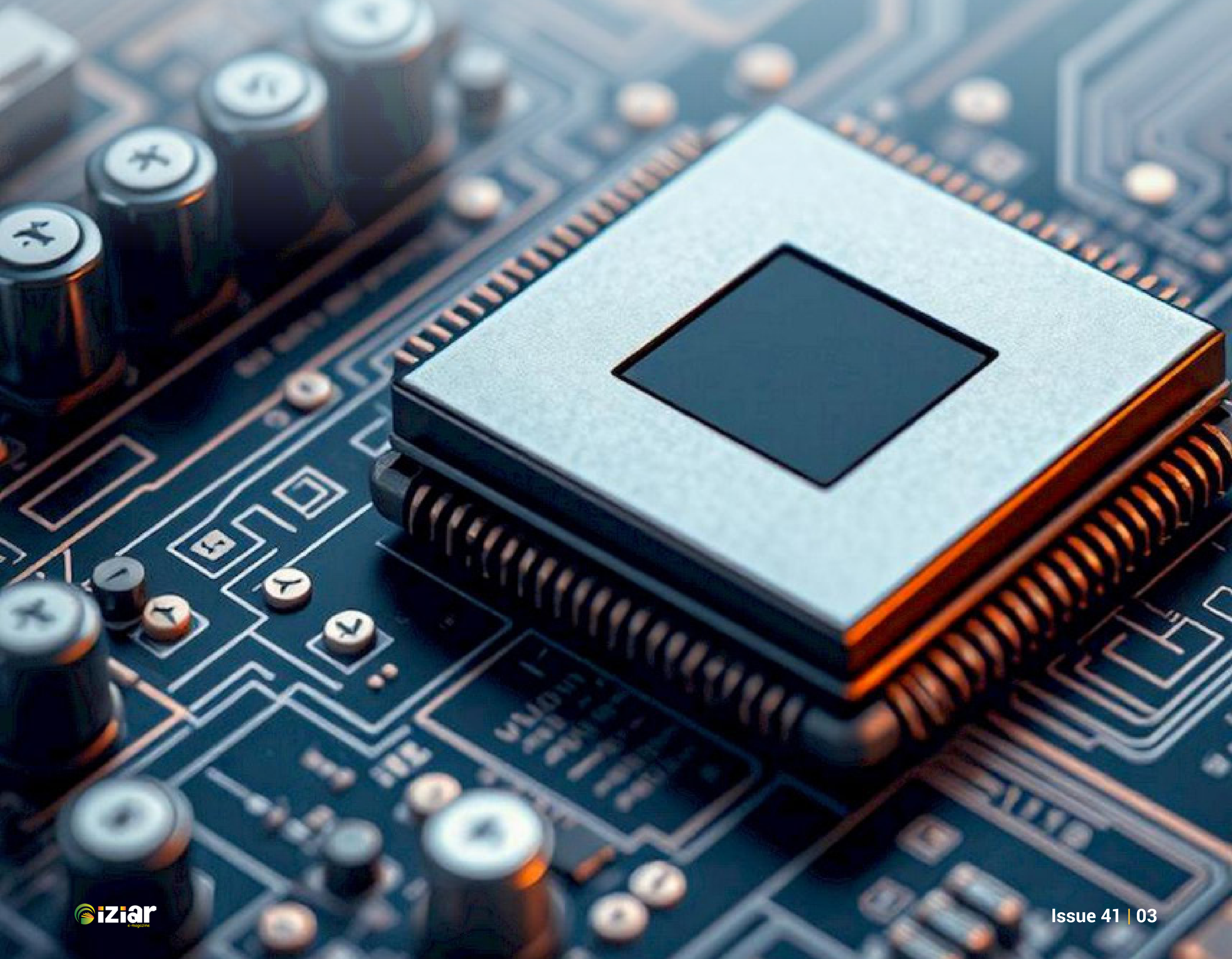
Silsa Shaji
Jr Project Engineer
Kochi

Detail-oriented Embedded Systems Engineer with a Postgraduate degree in Electronics and strong hands-on experience in embedded hardware, firmware development, and system-level testing through academic projects and internships. Skilled in interfacing microcontrollers, sensors, and peripherals, debugging hardware–software interactions, and validating embedded systems for functionality, reliability, and performance. Passionate about building robust embedded solutions and ensuring seamless real-time system behavior.

Artificial Intelligence (AI) has become a core enabler of intelligent decision-making in modern computing systems. Traditionally, AI workloads have been executed in centralized cloud infrastructures, where data collected from distributed devices is transmitted to remote servers for processing and inference. While this paradigm provides access to high-performance computing resources, it introduces several limitations, including increased latency, high bandwidth consumption, privacy concerns, and reliance on continuous network connectivity. These challenges have driven the evolution of Edge AI, a decentralized computing approach that enables AI inference directly on embedded systems located close to the data source.

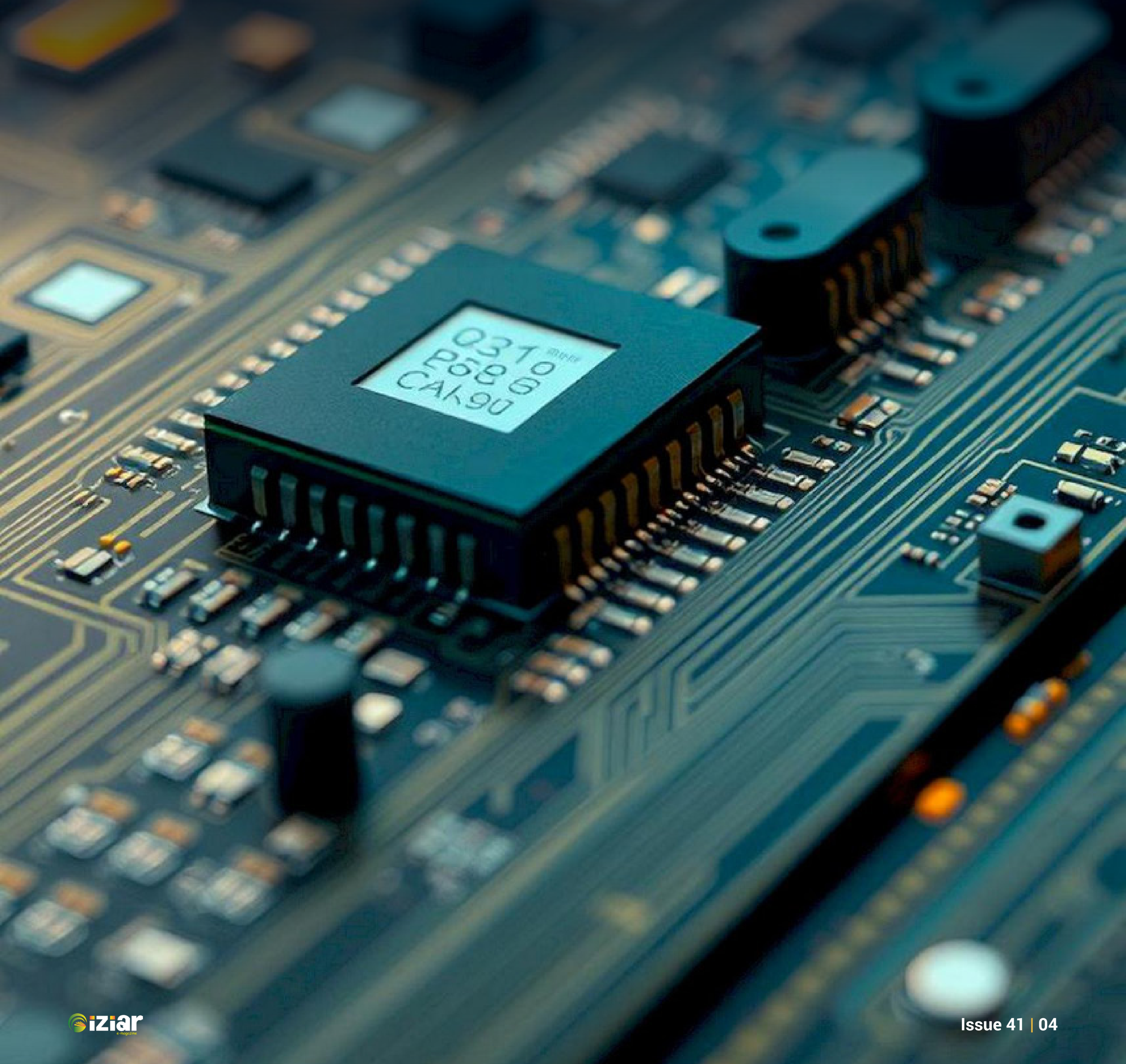
Edge AI refers to the deployment and execution of machine learning (ML) and deep learning (DL) models on edge-level embedded hardware. Embedded systems are specialized computing platforms designed to perform dedicated functions under strict constraints related to power consumption, memory capacity, processing capability, and real-time responsiveness. Common embedded platforms include microcontrollers (MCUs), microprocessors (MPUs), and system-on-chip (SoC) architectures. Historically, embedded systems have relied on deterministic logic, state machines, and threshold-based control algorithms. Although effective for predictable environments, such approaches are insufficient for handling complex, high-dimensional, and unstructured data generated by modern sensors.

The integration of AI into embedded systems enables advanced functionalities such as computer vision, speech recognition, anomaly detection, predictive maintenance, and intelligent control. However, executing these workloads through cloud-based AI introduces unacceptable delays in latency-sensitive and safety-critical applications, including autonomous vehicles, industrial automation, medical monitoring, and power systems. Edge AI addresses these limitations by allowing inference to be performed locally, thereby enabling real-time decision-making, enhanced system reliability, and improved data privacy.



The Edge AI workflow can be broadly divided into two distinct phases: offline model training and on-device inference. Model training is typically performed using large datasets on high-performance computing platforms such as GPUs, TPUs, or cloud-based AI infrastructure. During this phase, model parameters are optimized using supervised, unsupervised, or reinforcement learning techniques. Once trained, the model must be adapted for deployment on embedded hardware, which often has limited computational and memory resources.

Model optimization is a critical step in Edge AI deployment. Common optimization techniques include quantization, where floating-point operations are converted to fixed-point representations (e.g., INT8 or INT4), model pruning to remove redundant parameters, weight sharing, and compression. Operator fusion and architecture simplification further reduce inference latency and memory footprint. These optimizations enable AI models to execute efficiently on embedded platforms while maintaining acceptable accuracy levels.



On the embedded device, the inference pipeline begins with data acquisition from sensors such as cameras, microphones, accelerometers, temperature sensors, or industrial transducers. The raw sensor data undergoes preprocessing, which may include filtering, normalization, resizing, or feature extraction. The optimized AI model then performs inference using available processing units such as CPUs, digital signal processors (DSPs), graphics processing units (GPUs), or dedicated neural processing units (NPUs). The inference output is passed to decision logic modules that trigger control actions, alerts, or actuator responses in real time.

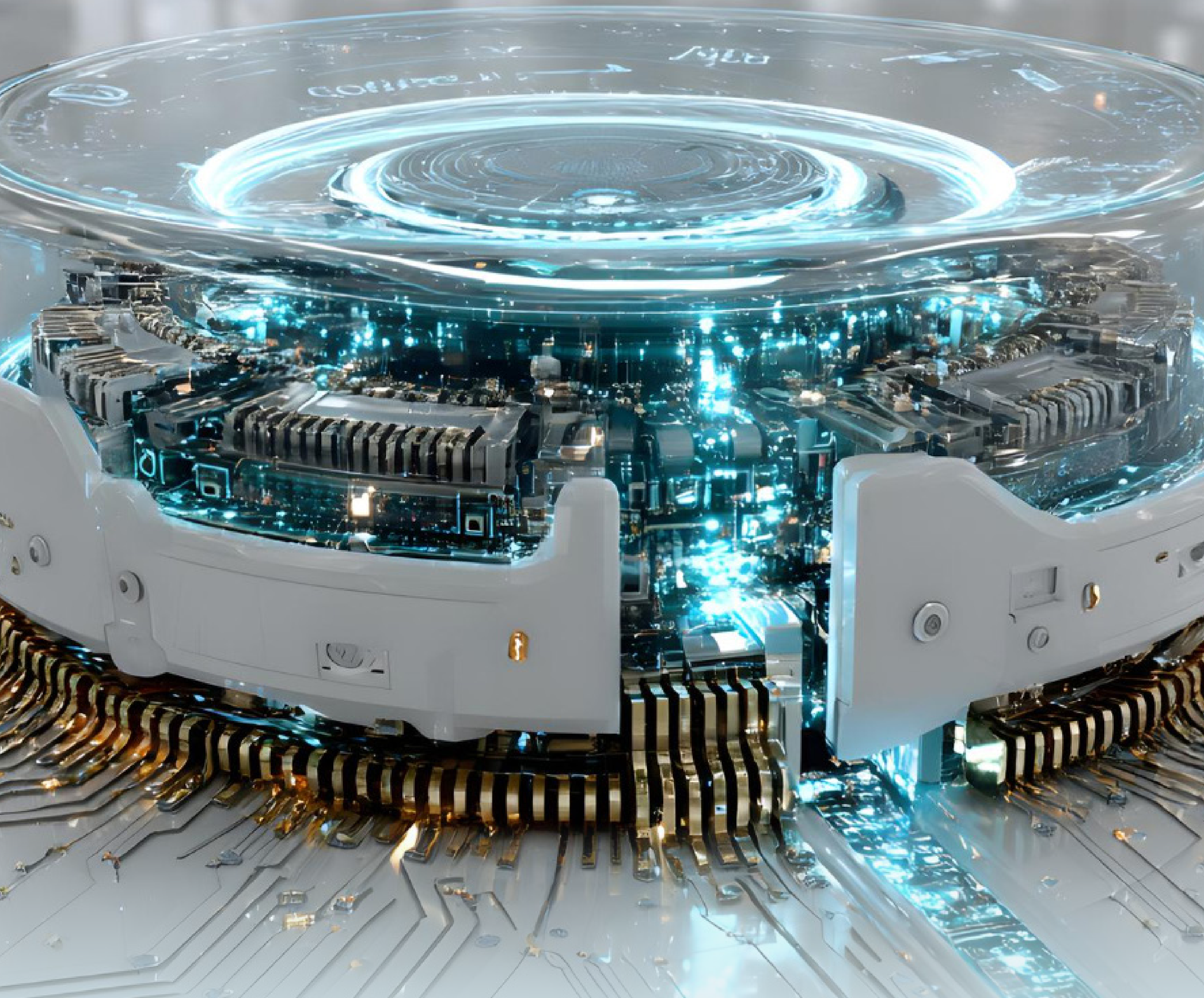
One of the most significant technical advantages of Edge AI is reduced latency. By eliminating the need for round-trip communication with cloud servers, Edge AI enables deterministic response times that are essential for real-time control systems. Additionally, Edge AI improves data privacy and security by keeping sensitive information such as biometric data, medical signals, or proprietary industrial data within the local device. This approach also reduces bandwidth usage and operational costs, as only inference results or exception events are transmitted to centralized systems.

Edge AI systems also offer improved robustness and fault tolerance. Embedded devices equipped with local intelligence can continue operating during network disruptions, making them suitable for remote, mobile, or mission-critical environments. Energy efficiency is another key benefit, as modern embedded AI accelerators and optimized inference engines are designed for low-power operation, enabling deployment in battery-powered and energy-constrained systems.

Despite its advantages, Edge AI presents several technical challenges. Embedded systems have limited memory, processing throughput, and thermal capacity, which restrict the complexity of deployable models. Maintaining inference accuracy after aggressive optimization remains a significant challenge. Furthermore, Edge AI systems must address issues related to real-time scheduling, secure model updates, lifecycle management, and model degradation due to changing real-world data distributions.

Recent advancements are addressing these challenges through the development of TinyML, ultra-low-power AI-enabled microcontrollers, and hardware-software co-design approaches. Emerging technologies such as neuromorphic computing and event-driven processing further extend the feasibility of intelligent processing at the extreme edge. As Industry 4.0, smart infrastructure, and autonomous systems continue to evolve, Edge AI is expected to become a foundational component of embedded system design.

In conclusion, Edge AI represents a paradigm shift from centralized intelligence to distributed, device-level cognition. By enabling real-time inference on embedded systems, Edge AI enhances system responsiveness, privacy, reliability, and scalability. As embedded hardware capabilities and AI software frameworks continue to advance, Edge AI will play a critical role in shaping the next generation of intelligent, autonomous, and connected systems.



Consciousness is not a Switch
It is a System

Ananda Sherin
Junior IT Engineer
Trivandrum

Ananda Sherin is a Jr. IT Engineer passionate about Human & AI collaboration to build smarter, efficient solutions. Skilled in supporting IT systems, automation, and emerging technologies with a problem-solving mindset. Enthusiastic about learning, adapting, and applying AI tools to real-world challenges. Believes in blending human creativity with AI intelligence to drive innovation and growth. Always eager to contribute to dynamic teams and evolving tech environments

Artificial Intelligence, or AI, is now part of our everyday life. It helps us search for information, talk to others, learn new things, and make decisions. AI can answer questions, write content, recognize faces, and even drive cars. Because of this, many people feel that AI is becoming "human-like".

This brings a new and important question

Can AI ever become conscious and aware like humans? Can human memories be stored or shared with AI?

These questions are no longer only part of movies or stories. Engineers, scientists, and researchers are now discussing them seriously.

Understanding Intelligence, Consciousness, and Awareness

To understand this topic, we must first know the meaning of some simple words.

- **Intelligence** means the ability to solve problems.
- **Consciousness** means having experiences.
- **Awareness** means knowing that "this experience is happening to me"

AI today is intelligent. It can solve problems very fast. But AI is not conscious. AI is not aware. AI works, but it does not know that it is working.

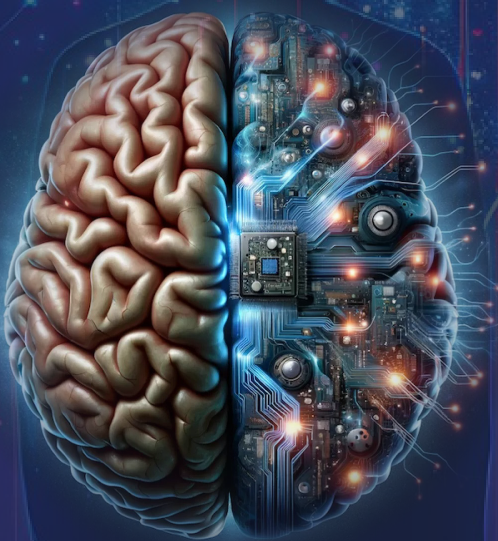
Consciousness Is a System, Not a Switch

In the past, people believed consciousness worked like a switch.

ON → conscious

OFF → not conscious

Modern science does not agree with this idea. Today, consciousness is explained as a system. This system includes: Input from the world, brain signals, memory, learning, awareness, action and feedback. When all these parts work together, consciousness exists. If one important part is missing, consciousness changes.



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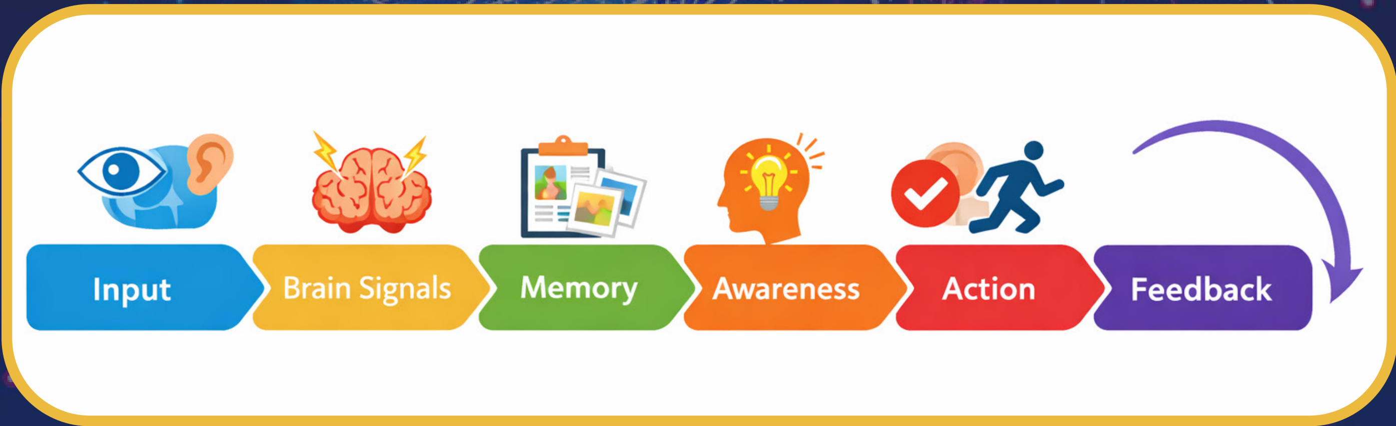
How Humans Become Aware

The human brain has billions of small cells called neurons. These neurons send signals to each other. No single neuron creates awareness. Awareness happens when the brain watches its own activity, connects past memory with present input, and understands "this is happening to me now". This ability to watch itself is called self-awareness.

Simple View of Awareness

The human thinking process can be explained in a simple way:



- **Input:** what we see, hear, or feel
- **Brain signals:** messages inside the brain
- **Memory:** storing past experiences
- **Awareness:** knowing what is happening
- **Action:** responding to the situation
- **Feedback:** learning from the result

This loop runs again and again. If awareness is missing, the system still reacts, but it does not know that it is reacting.

How AI Works Today

AI systems today work in a very different way from humans.

AI uses: Data, Rules, Mathematical models

AI is good at: Finding patterns, Predicting results, Making fast decisions

AI cannot: Feel pain, Feel happiness, Know it exists

Even if AI says "I understand", It is only producing words based on data.There is no inner experience inside AI.

Memory: A Key Part of Consciousness

Memory is very important for humans. Memory helps us recognize people, remember events, learn from mistakes, and build our identity. Without memory, awareness becomes weak. This is why memory is a key idea when talking about AI and consciousness.

Memory Transfer: What Does It Really Mean?

Many people misunderstand memory transfer. Memory transfer does not mean moving feelings into AI or giving AI emotions or making AI human. Memory transfer means something much simpler. It means saving photos, videos, and voice, storing stories and personal knowledge, keeping records of experiences. This creates digital memory, not human memory.

Simple Idea of Memory Transfer

The idea can be explained very simply:

Human Memory → Digital Storage → AI System

- The human brain keeps real experience
- Digital storage keeps information
- AI uses this information to respond

AI does not feel these memories. AI only uses stored data to give answers. This is not copying consciousness. It is preserving memories.

Can AI Use Human Memories?

Yes, AI can use stored human memories in limited ways. For example answering questions based on stored data, reminding people of past events, helping people remember important information. But AI does not understand these memories emotionally. AI treats memory as data, not experience.

Can AI Become Aware in the Future?

This question does not have a clear answer yet. Scientists and engineers have three main ideas:

1. **AI may never become aware**
   Some believe awareness needs a biological brain.
2. **Awareness may appear in complex systems**
   Very large and complex systems may develop awareness.
3. **AI may get a different kind of awareness**
   Machine awareness may not feel like human awareness.

At present, none of these ideas are proven.

Why Awareness Is Hard to Measure

Engineers like things they can measure. But awareness cannot be measured. There is no tool to measure inner experience, feelings, or self-awareness. Because of this, even if AI becomes aware one day, we may not be able to prove it easily.

Why Engineers Must Be Careful

If a machine becomes aware it cannot be treated as a simple tool. Ethical questions become serious. Control becomes very important. That is why engineers focus on safe AI, human control, clear rules and limits. The goal is helpful AI, not harmful systems.

Why This Research Is Important

Studying consciousness and memory helps humans in many ways. It helps to understand the human brain better, improve mental health tools, protect human memories, build safer and more responsible AI. Even if AI never becomes aware, this research is still useful.

Conclusion: A Careful and Hopeful Future

AI today is intelligent, but not aware. In the future, AI may develop a form of awareness. Human memories can be stored digitally, but human consciousness remains unique. The goal of AI is not to replace humans. It is to support human life, learning, and memory. Understanding consciousness and memory helps us build a better future.That future is not scary. It is careful, responsible, and hopeful.

From Automation to Intelligence
How AI Is Quietly Redefining Everyday Work

Chandana P
Technical Lead
Mysore

I work with Python, Machine Learning, and SQL to build data-driven solutions and help solve real-world problems. Over time, I've developed a strong interest in Machine Learning and Deep Learning, and I continue to build on that knowledge through hands-on work and ongoing learning. Lately, I've been exploring new developments in AI and keeping up with technologies that are shaping the future of data science. I'm also focusing on improving how insights are shared—currently learning Power BI and Tableau to create clear, useful visualizations and dashboards that support better decision-making. My approach is practical, and my goal is to keep growing while contributing to meaningful, data-based solutions.

Introduction: The AI Shift We Hardly Notice

Artificial Intelligence is no longer something we "use" consciously at work—it is something we work with, often without realizing it. From emails that draft themselves to calendars that anticipate our schedules, AI has seamlessly blended into our everyday professional routines. Unlike earlier waves of technological change that arrived with disruption and noise, this transformation is quiet, gradual, and deeply integrated.

What makes this shift remarkable is not its speed, but its subtlety. Employees are not being asked to learn complex systems overnight. Instead, intelligence is embedded into familiar tools, enhancing how we write, plan, analyse, and communicate. The workplace has moved beyond basic automation into an era where systems can understand context, learn patterns, and support better decision-making.

This article explores how AI is redefining everyday work—not by replacing people, but by empowering them to work smarter, faster, and with greater focus.

Automation vs Intelligence: What Changed?

For years, offices relied on automation to improve efficiency. Automation followed predefined rules: if X happens, do Y. Examples include payroll processing, attendance tracking, or scheduled email alerts. These systems were effective, but limited—they could not adapt beyond what they were programmed to do.

Artificial Intelligence represents a fundamental shift. Intelligent systems learn from data, recognize patterns, and improve over time. Instead of rigid instructions, AI works with probabilities and context. It can suggest actions, predict outcomes, and adapt to changing situations.

For example, traditional automation sends reminder emails at fixed times. Intelligent systems prioritize emails based on urgency, summarize long conversations, and even recommend responses. The difference is not just speed, but understanding.

This transition from automation to intelligence marks a move from mechanical efficiency to cognitive support—bringing technology closer to how humans actually think and work.

AI in Everyday Office Tools

AI is already present in many tools, employees use daily:

- **Email & Communication :** Smart replies, spam filtering, email prioritization, and tone suggestions reduce time spent managing inboxes.
- **Meetings:** Automatic transcription, real-time captions, action-item summaries, and follow-up reminders help teams stay aligned.
- **Documents & Reports:** AI-assisted drafting, formatting, grammar correction, and data summarization accelerate content creation.
- **Task Management:** Intelligent reminders, deadline predictions, and workload balancing help employees plan more effectively.

These features do not demand technical expertise. They work quietly in the background, allowing employees to focus on meaningful tasks rather than repetitive administrative work.

The result is a smoother workflow—less friction, fewer errors, and improved clarity across teams.

Productivity: Reality vs Expectations

AI is often associated with dramatic productivity gains, but the reality is more nuanced. While AI can save time, its true value lies in how that time is used.

AI reduces cognitive overload by handling routine tasks, but productivity does not automatically increase unless employees consciously redirect their freed-up time toward high-impact work. Simply working faster is not the same as working better.

Another misconception is that AI eliminates effort. In reality, effective use of AI still requires human judgment—knowing what to ask, how to interpret outputs, and when to override suggestions.

When used thoughtfully, AI becomes a productivity partner, not a shortcut. Organizations that focus on quality of work, not just speed, see the greatest benefits.

Human + AI : Collaboration, Not Competition

One of the biggest fears surrounding AI is job replacement. However, in most office environments, AI is not replacing roles—it is reshaping them.

AI excels at processing large volumes of information, identifying patterns, and performing repetitive tasks. Humans excel at creativity, empathy, ethical reasoning, and strategic thinking. The most successful workplaces combine these strengths.

For example:

- AI can analyse data trends, but humans decide strategy.
- AI can draft content, but humans refine messaging.
- AI can suggest solutions, but humans assess real-world impact.

This collaboration allows employees to operate at a higher level—moving from execution to insight, from routine to innovation.

How AI Is Changing Roles, Not Removing Them

Rather than eliminating jobs, AI is evolving job roles. Many positions are shifting focus from manual execution to oversight, analysis, and decision-making.

Roles increasingly emphasize:

- Interpreting AI-generated insights
- Managing intelligent systems
- Applying human judgment to automated outputs
- Continuous learning and adaptability

New responsibilities are emerging alongside AI adoption, such as data stewardship, ethical oversight, and cross-functional collaboration.

Employees who embrace learning and flexibility are finding new growth opportunities. The future belongs not to those who resist AI, but to those who learn how to work alongside it.

Ethical & Responsible Use of AI at Work

As AI becomes more embedded in workplace systems, ethical considerations grow increasingly important.

Key concerns include:

- **Data Privacy:** Ensuring sensitive employee and customer data is protected.
- **Bias & Fairness:** Preventing AI systems from reinforcing existing inequalities.
- **Transparency:** Understanding how decisions are made by intelligent systems.
- **Accountability:** Defining who is responsible for AI-driven outcomes.

Responsible AI use requires clear policies, regular audits, and a culture of trust. Employees should feel confident that AI tools are designed to support them—not monitor or disadvantage them.

Ethical AI is not just a technical issue; it is a leadership responsibility.

Skills Employees Need in the AI Era

The rise of AI does not demand that everyone become a programmer. Instead, it highlights the importance of AI literacy—understanding what AI can and cannot do.

Key skills for the modern workplace include:

- Critical thinking and problem-solving
- Adaptability and continuous learning
- Effective communication
- Creativity and innovation
- Ethical awareness and decision-making

Employees who combine domain expertise with AI awareness are better equipped to navigate change and add long-term value to their organizations.

The Indian Workplace Perspective

In India, AI adoption is accelerating across industries—from IT and finance to healthcare and education. Indian workplaces are uniquely positioned to benefit from AI due to a strong talent pool and a growing digital ecosystem.

However, challenges remain:

- Skill gaps and training needs
- Cultural hesitation toward automation
- Infrastructure and data readiness

Organizations that invest in upskilling, transparency, and inclusive adoption are seeing positive outcomes. AI, when aligned with India's workforce strengths, has the potential to enhance productivity while preserving human-centric values.

Conclusion: Staying Relevant in an Intelligent Workplace

The shift from automation to intelligence is not a future event—it is already here. AI is quietly reshaping how work gets done, how decisions are made, and how employees contribute.

Success in this new era does not depend on competing with machines, but on collaborating with them. Employees who stay curious, adaptable, and ethically grounded will continue to thrive.

Ultimately, intelligence at work is not about replacing people—it is about empowering them. The organizations that understand this will not just adopt AI; they will grow with it.

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Gamification in Recruitment

A Modern Approach to Student Placements

Thana Anjana
Placement Officer
Tirunelveli

As a dedicated Placement Officer, I specialize in bridging the gap between academic talent and industry requirements. My expertise lies in building strong corporate partnerships, understanding hiring needs, and guiding students toward meaningful career opportunities. With a results-driven approach, I focus on end-to-end placement coordination, employability enhancement, and successful talent deployment across diverse industries.

In today's rapidly evolving hiring landscape, traditional recruitment methods are no longer sufficient to attract, assess, and retain top student talent. Organizations across the world are searching for innovative ways to make the placement process more efficient, engaging, and reflective of real workplace skills. One such modern strategy that has gained significant momentum is gamification. Gamification refers to the integration of game elements—such as challenges, leaderboards, badges, competitive assessments, real-time feedback, and simulations— into non-gaming contexts. In recruitment and campus placements, it represents a transformative shift from standard assessments to learning-based, interactive experiences that give recruiters a clearer understanding of a candidate's real capabilities.

Traditionally, campus placements were heavily dependent on written tests, interviews, and group activities. While these tools are useful, they often fail to assess key attributes such as creativity, critical thinking, agility, decision-making under pressure, and practical knowledge application. The current generation of students has grown up with technology, smartphones, gaming applications, and online learning platforms. Gamification taps directly into this familiarity. Instead of telling candidates what a company values, it shows them, allowing recruiters to observe how students perform in real or simulated scenarios rather than just listening to theoretical answers.

One major reason organizations are adopting gamification in hiring is that it reduces hiring bias and increases fairness. Traditional interviews can sometimes be influenced by personal impressions, communication styles, or subjective judgments. Gamified assessments, however, rely on measurable performance scores and actions taken during standardized challenges. This helps companies evaluate candidates more objectively and provides students with a level playing field irrespective of academic background or communication style.

Another compelling benefit is that gamification enhances candidate engagement and participation. Placement season can often be stressful for students, filled with multiple tests, competitive screening, and back-to-back interviews. Conventional written tests may feel monotonous and intimidating. Gamified recruitment, on the other hand, offers a refreshing and motivating experience. It turns assessments into an interactive journey where students feel like active participants rather than anxious test-takers. For example, instead of solving a theoretical business case on paper, a student might participate in a virtual business simulation game where they make decisions for a company, navigate real challenges, and achieve measurable results. This increased engagement helps students perform more naturally while offering recruiters deeper insights into how they think and execute tasks.

Gamification is also helping bridge the long-standing gap between classroom learning and industry expectations. Many students complete their education with strong theoretical knowledge but limited exposure to real workplace problem-solving. By incorporating realistic games and simulations, organizations give students a chance to demonstrate their applied skills rather than just academic knowledge. For instance, a company seeking data analysts might present students with a gamified dataset challenge where they must clean data, identify trends, and present insights within a time limit. Similarly, a digital marketing role might involve virtual campaigns where candidates compete to optimize engagement and conversions. These experiences not only test real- world skills but also allow students to understand what the job truly demands, thereby setting realistic expectations before employment.

The use of gamification is also proving beneficial for employer branding. In today's competitive hiring environment, students are selective about the organizations they want to join. A company that offers engaging, technology-driven recruitment experiences is seen as modern, progressive, and employee-friendly. This improves student perception and enhances the company's ability to attract top talent. Many leading companies—including Deloitte, Accenture, Google, PwC, and several startups—have already integrated gamification into their hiring process with outstanding results. Their success has encouraged many educational institutions and training academies to design gamified learning interventions for students in advance, helping them become industry- ready before placements even begin.

Recruiters also benefit from the data-driven insights generated through gamified assessments. These tools can capture detailed behavioral data, including how candidates prioritize tasks, whether they take risks or play safe, how quickly they make decisions, and how effectively they collaborate in team-based challenges. Such quantitative insights help hiring managers develop a more comprehensive evaluation of each candidate. Modern gamified platforms even offer analytics dashboards that compare peer performance, highlight skill strengths, and identify capability gaps. This helps organizations select better matches for the role while giving students constructive feedback about areas where they can improve.

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Gamification is also proving extremely valuable in reducing candidate drop-off rates. Students often lose interest when hiring processes are too lengthy or repetitive. However, when the journey includes progressive levels, digital achievements, instant scoring, and a sense of accomplishment, they are more likely to stay motivated and complete the selection pipeline. This is particularly beneficial in large-scale campus hiring scenarios where companies need to screen thousands of students at once. Gamification makes the process more manageable, enjoyable, and scalable for both candidates and recruiters.

Of course, like any talent strategy, gamification is not without challenges. Implementation requires strategic design, reliable technology, and accurate performance metrics. Poorly structured games may confuse candidates or fail to align with job expectations. Recruiters must ensure that gamified assessments test real competence and not just entertainment value. However, when designed effectively, gamification delivers stronger hiring outcomes, higher engagement, improved employer image, and better long-term retention of hired candidates.

In conclusion, gamification is shaping the future of student placements by making recruitment more interactive, transparent, and skill-oriented. It ensures that the selection process evaluates what truly matters—practical ability, adaptability, problem-solving, and readiness for dynamic work environments. As industries continue to adopt technology-driven hiring, organizations and educational institutions that embrace gamified recruitment processes will have a significant advantage in identifying the right talent and preparing students for the workforce of tomorrow.

Securing Industrial Control Systems in the Age of Industry 4.0

Manu Mahadevan
Project Engineer
Kochi

Automation & BMS Engineer with 1.6 years of hands-on experience in Building Management Systems (BMS) and industrial automation. Experienced in installation, commissioning, testing, troubleshooting, and maintenance of automation systems for commercial and industrial projects. Strong understanding of PLCs, sensors, controllers, and field devices with a focus on energy efficiency and system reliability.

Industrial Control Systems (ICS) are the foundation of modern industrial operations, responsible for monitoring and controlling physical processes across manufacturing plants and critical infrastructure. Systems such as Programmable Logic Controllers (PLCs), Distributed Control Systems (DCS), Supervisory Control and Data Acquisition (SCADA), and Safety Instrumented Systems (SIS) ensure continuous, reliable, and safe operation in industries including power generation, oil and gas, chemicals, pharmaceuticals, water treatment, and transportation.

With the rapid adoption of Industry 4.0, these traditionally isolated systems are now increasingly connected to enterprise IT networks, cloud platforms, and Industrial Internet of Things (IIoT) ecosystems. While this digital transformation enables advanced analytics, predictive maintenance, and greater operational flexibility, it also introduces significant cyber security challenges. Securing industrial control systems has therefore become a critical requirement for operational continuity, safety, and regulatory compliance.

Evolution of Industrial Control System Architectures

Historically, ICS environments were designed as closed systems. Proprietary hardware, vendor-specific protocols, and physical isolation from external networks provided a degree of inherent security. Cyber threats were not a primary design consideration, as systems operated within well-defined plant boundaries and relied heavily on procedural and physical controls.

Industry 4.0 has fundamentally altered this architecture. Modern industrial environments integrate PLCs, DCS controllers, and RTUs with smart field devices, industrial Ethernet networks, wireless communication, edge computing platforms, and cloud-based services. Protocols such as PROFINET, EtherNet/IP, Modbus TCP, and OPC UA enable high-speed data exchange across multiple layers of the automation pyramid. Remote monitoring, vendor access, and centralized analytics have become common operational requirements.

This convergence of Information Technology (IT) and Operational Technology (OT) delivers unprecedented visibility and efficiency, but it also expands the attack surface. Control systems that were never designed to withstand cyber attacks are now exposed to threats originating both inside and outside the organization.

Unique Cybersecurity Challenges in ICS Environments

Securing industrial control systems differs significantly from securing traditional IT systems. ICS environments operate under strict real-time constraints, where availability and determinism are often more critical than confidentiality. System downtime, unexpected reboots, or delayed responses can directly impact production, safety, and equipment integrity.

Additionally, many industrial systems have long life cycles, often exceeding 15 to 20 years. Legacy controllers and operating systems may no longer receive security patches, yet remain critical to plant operations. Applying updates or security controls without proper testing can introduce operational risks, making patch management a complex challenge.

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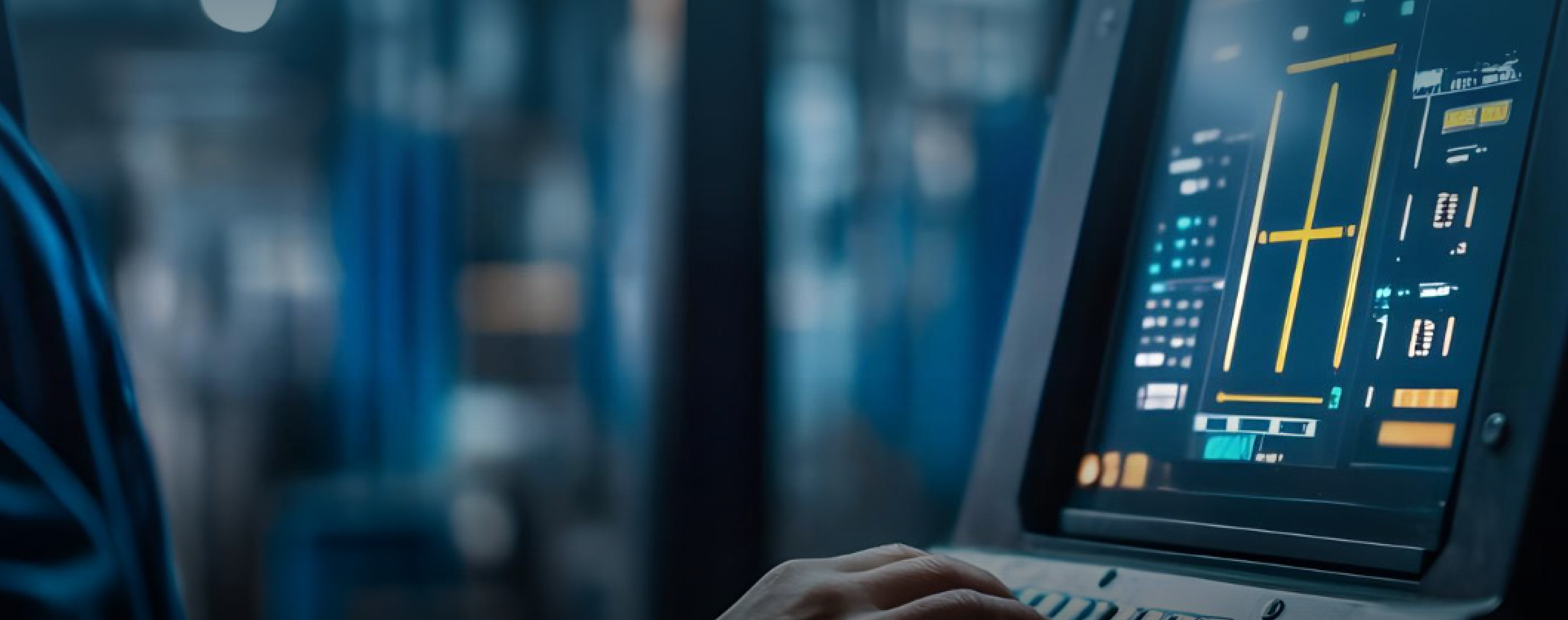

Cyber Threats Targeting Industrial Control Systems

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Key Principles for Securing Industrial Control Systems

Effective ICS cybersecurity requires a layered, defense-in-depth approach tailored to operational realities. Network segmentation is a fundamental principle, separating enterprise IT systems from OT networks using firewalls and demilitarized zones (DMZs). Critical controllers and safety systems should be placed in protected zones with strictly controlled communication paths.

Secure remote access is another essential component. Remote connectivity should be implemented using virtual private networks (VPNs), strong authentication, and session monitoring. Direct exposure of control systems to the internet should be strictly avoided.

Asset visibility is critical for risk management. Organizations must maintain an accurate inventory of controllers, field devices, firmware versions, and network connections. Passive monitoring tools can help detect anomalies and unauthorized activities without impacting real-time operations.

Access control and system hardening reduce the risk of unauthorized changes. Role-based access, least-privilege principles, controller program protection, and secure configuration management are essential practices in industrial environments.

Standards and Frameworks for ICS Security

International standards and guidelines provide structured approaches to securing industrial control systems. The IEC 62443 series defines requirements for secure system design, integration, and operation across the entire automation life cycle. NIST SP 800-82 offers practical guidance for securing ICS in critical infrastructure sectors, while ISO/IEC 27001 supports broader information security management.

Adopting these frameworks helps organizations align technical controls, policies, and operational procedures, enabling consistent and measurable cyber risk management.

Conclusion

As Industry 4.0 continues to reshape industrial operations, securing industrial control systems has become a strategic imperative. Cyber security incidents in ICS environments can lead to operational downtime, safety hazards, quality issues, and significant financial and reputational damage.

Protecting control systems requires more than traditional IT security measures. It demands a deep understanding of industrial processes, system behavior, and operational constraints. By embedding cyber security into system design, operations, and maintenance, organizations can build resilient, secure, and intelligent industrial environments capable of supporting innovation and sustainable growth in the digital age.

Madhu Manas Pradeep
Jr. Project Engineer
Trivandrum

I am a Junior Project Engineer at IPCS Global, working in industrial automation and control systems. I completed my Bachelor of Technology in Applied Electronics and Instrumentation from the University of Kerala and my Master of Engineering in Network Engineering from the University of Canberra, which gave me a strong foundation in communication networks, systems design, and problem solving. This background now helps me understand industrial networks, protocols, and how different devices talk to each other in automation projects.

Before joining IPCS Global, I gained experience in industrial automation and related technologies through roles and projects focused on PLCs, SCADA systems, and building management or security systems, which showed me the importance of combining technical skills with clear communication, documentation, and teamwork when dealing with clients and on site teams. Outside of work, I am passionate about railways, enjoy playing table tennis, and like creating technical content that simplifies automation concepts for beginners while exploring how Industry 4.0 and data driven approaches can make systems smarter, more efficient, and more reliable.

In the long term, I see myself growing into a lead automation engineer who can handle complex projects end to end while mentoring the next generation of engineers. Green Earth in PLC logic, for me, is about using control programs not just to run machines reliably, but to reduce waste, conserve energy, and encourage cleaner sources like solar and wind wherever possible, so that every cycle is a little kinder to the environment.

Green Earth in PLC Logic Programming for a Sustainable Future

What green earth means to me

For me, a green earth in automation starts with a simple question: "Can this process run with fewer kilowatts, fewer raw materials, and fewer emissions, without sacrificing safety or quality?" PLCs sit exactly at that decision point, because every motor start, every valve position, and every heater output is ultimately decided by logic written in a program.

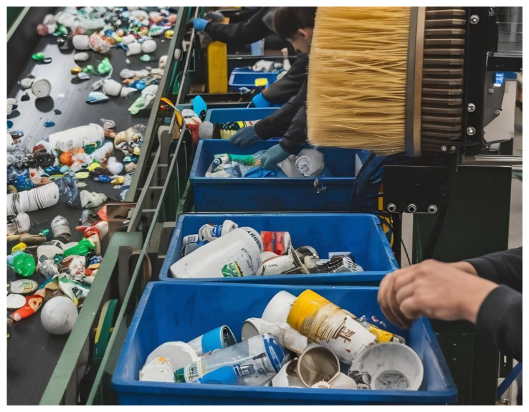
When I write PLC logic now, I try to think beyond "on/off" control and imagine the electrical and environmental footprint behind each coil and contact. A poorly thought-out rung might mean a motor idling for hours with no product, a compressor loading when there is no real demand, or lights burning in an empty area—all of these are tiny but continuous hits on the planet.

How PLCs can reduce waste

PLCs are already very good at repeatability, and that is a surprisingly powerful sustainability tool. When a process is stable and repeatable, scrap reduces, rework decreases, and material usage becomes predictable, which directly lowers waste and energy consumption per good product.

In my view, three practical ideas stand out:

- Turn things off automatically when they are not needed: conveyors, pumps, lights, HVAC zones, and auxiliary equipment can all be interlocked to actual demand instead of running by default. A simple idle timer and permissive logic can remove hundreds of hours of needless operation per year.
- Avoid peak and blind operation: with a bit of logic around time-of-day and load thresholds, PLCs can shift some high-consumption tasks away from peak tariff windows, indirectly reducing stress on the grid and fossil-based generation.
- Reduce "hidden" waste: soft-starting motors, coordinating sequences to avoid simultaneous large starts, and preventing short-cycling of compressors or chillers all improve efficiency and extend equipment life, which means fewer replacements and less e-waste.



Writing energy-aware PLC logic

From a programming perspective, green thinking can actually be translated into structured patterns inside the PLC. Instead of treating energy as something managed externally by an energy team, it becomes a real variable in the control strategy.

Some patterns that I see as essential:

- **Demand-based control:** logic that starts machines only when an upstream or downstream condition truly requires it, such as minimum queue lengths, tank levels, or airflow requirements, rather than simple manual starts.
- **Load shedding and prioritisation:** during high demand situations, the PLC can temporarily disable non-critical loads (for example, auxiliary fans, secondary conveyors, or comfort cooling) while protecting critical production or safety functions.
- **Speed instead of start/stop:** whenever variable frequency drives or servo systems are available, PLC logic can modulate speed instead of repeatedly starting and stopping motors, which is usually more efficient and gentler on the mechanical system.

Even in ladder logic, this can be cleanly implemented with well-named tags like:

- "Energy_Save_Mode"
- "Peak_Hour,"
- "NonCritical_Load_Enable,"

so that energy behaviour is visible and tunable rather than buried in obscure conditions.

Integrating renewables and green technology

Green earth in PLC logic also means being ready for a future where renewable energy is normal inside plants, not an exotic add-on. Today, PLCs can already decide which power source to prioritise—solar, grid, or diesel—based on availability, cost, and load, and the logic can be written to always prefer the cleanest option first.

On the process side, automation is becoming a backbone for technologies like:

- Smart solar tracking and pitch control for wind, where PLCs continuously adjust position for maximum energy capture, reducing the cost and variability of green power.
- Continuous emissions monitoring and combustion optimisation in boilers and furnaces, where tighter control reduces excess air, fuel use, and pollutant emissions per unit of production.

In all these cases, the PLC is not just “following orders”; it is actively optimising in real time to keep the plant productive while lowering the environmental impact per cycle.

Mindset of a green automation engineer

Ultimately, green earth in PLC logic is less about a specific instruction set and more about a mindset that mixes engineering discipline with environmental responsibility. The same tools used to squeeze a few more units per hour out of a line can also be used to shave kilowatts, reduce scrap, and extend the life of equipment, if energy and sustainability are treated as real design specifications and not afterthoughts.

As an automation engineer, that means asking a few questions before calling a project "done":

- Did this sequence minimise idle running?
- Could a small change in timing reduce peaks?
- Did the logic give operators visibility into energy behaviour so they can improve it further?

When those questions become part of normal PLC design, each piece of code quietly pushes the plant, and the planet, a little closer to the green earth everyone talks about, but only a few actually engineer for.

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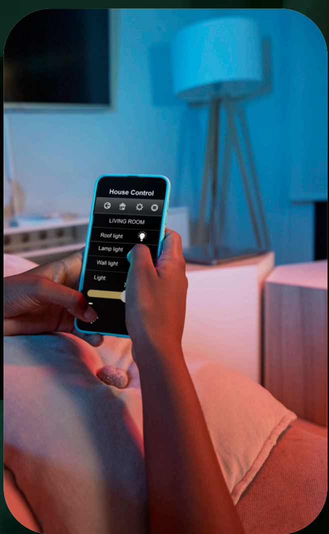

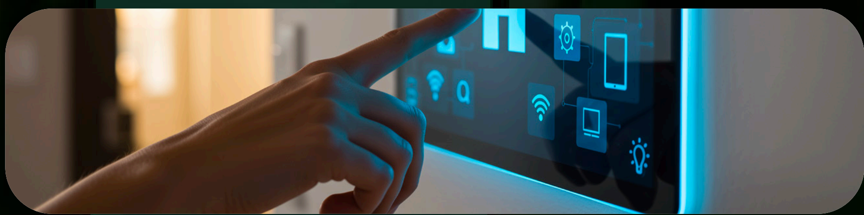

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Integrating Edge Computing into PLC – SCADA Architectures

Paul Manuel
Project Engineer
Mysore

I am an enthusiastic advocate of industrial automation and robotics, dedicated to harnessing intelligent systems to achieve precision and foster innovation. My professional repertoire encompasses the programming, calibration, and troubleshooting of PLCs, the deployment and integration of SCADA systems and possess advanced designing and implementing of human-machine interfaces (HMIs). Furthermore, I am skilled in the conceptualization and assembly of control panels and possess profound knowledge of the Robot Operating System (ROS), including navigation algorithms and mobile robot localization. My focus encompasses diverse facets of industrial environments wherein Programmable Logic Controllers (PLCs) are seamlessly integrated with real-time operational scenarios, complemented by the strategic deployment of SCADA systems. Through the meticulous selection and application of precise communication protocols and modalities, I endeavor to transmute complex industrial challenges into efficacious, real-time solutions.

Industrial automation has traditionally relied on a stable and proven architecture: field devices feed real-time data into Programmable Logic Controllers (PLCs), while SCADA (Supervisory Control and Data Acquisition) systems provide monitoring, visualization, and supervisory control across the plant.

While this architecture remains reliable, modern manufacturing environments demand faster insights, lower latency, and intelligent decision-making—requirements that stretch the limits of conventional designs.

This is where edge computing introduces a transformative new layer. Positioned between PLCs and SCADA systems, edge devices enable real-time analytics, AI-driven intelligence, and autonomous decision support, without relying solely on cloud connectivity. This emerging layer is reshaping how industrial systems operate.

The Evolution of the Industrial Automation Stack

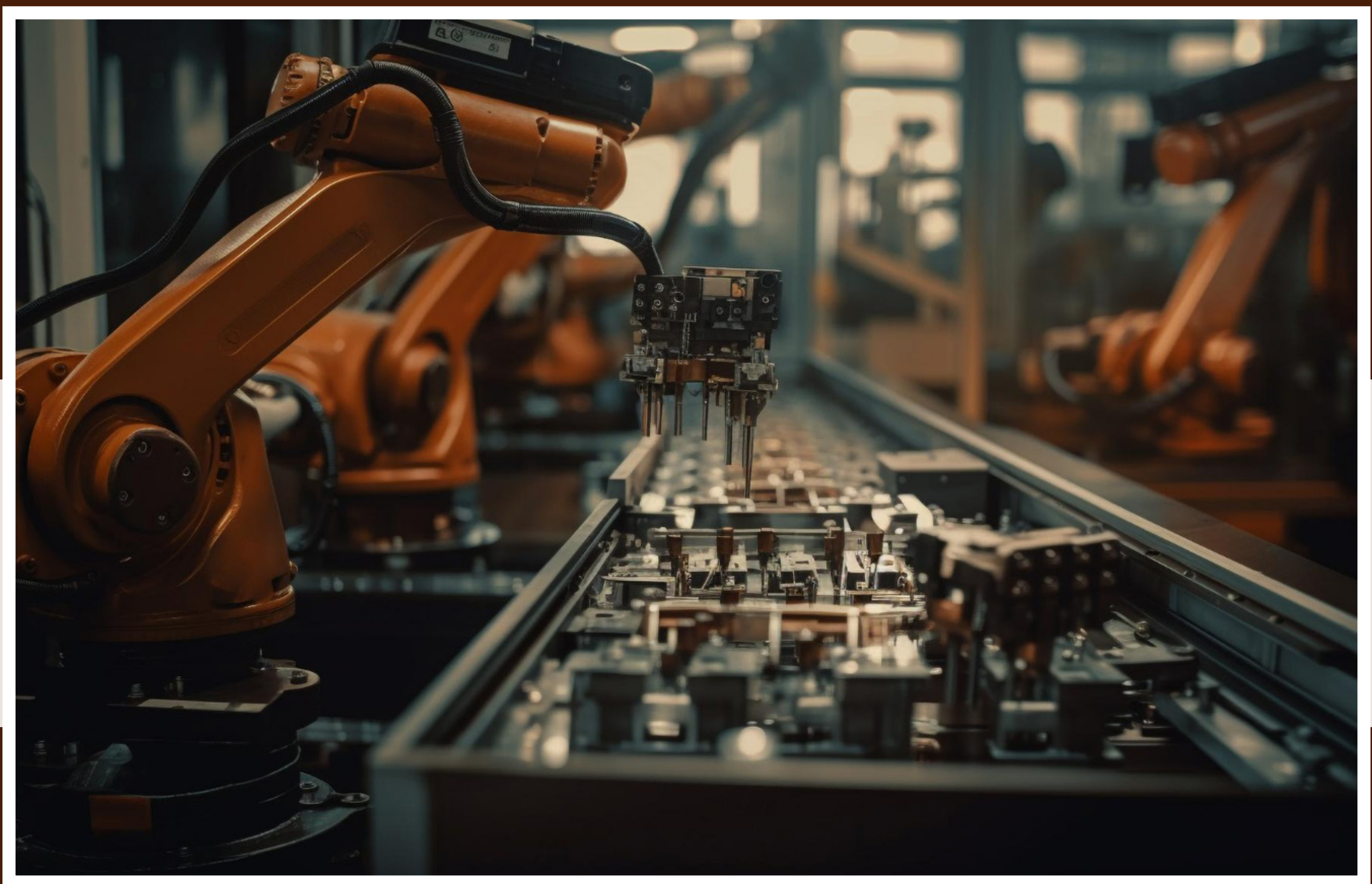
In classical automation architectures

- PLCs are optimized for deterministic control, real-time response, and high reliability
- SCADA systems focus on visualization, alarms, historical data, and operator interaction
- Advanced analytics and optimization, if present, are typically performed offline or in centralized servers

With the rise of Industry 4.0 and Industrial Internet of Things (IIoT) initiatives, machines now generate massive volumes of high-frequency operational data. Pushing all this raw data directly to SCADA systems or cloud platforms introduces challenges such as:

- Network bandwidth limitations
- Increased latency
- Cybersecurity exposure
- Scalability and performance constraints

Edge computing addresses these challenges by acting as an intelligent intermediary. Edge devices sit physically and logically close to machines, ingest data directly from PLCs, perform advanced local processing, and forward only meaningful insights to SCADA or higher-level systems. This enhances responsiveness and intelligence without disrupting proven control architectures.



Pre-Processing PLC Data: From Raw Signals to Actionable Insights

PLCs generate continuous streams of raw signals—temperatures, pressures, motor currents, vibration data, and more. Traditionally, SCADA systems handled aggregation and interpretation, but increasing data volumes and analytics complexity make this approach inefficient.

Edge devices bridge this gap by pre-processing data locally, offering several advantages:

- **Noise filtering and signal conditioning**

Cleans and smooths raw sensor data in real time before forwarding it upstream.

- **Protocol translation**

Converts legacy or proprietary protocols into modern standards such as OPC UA or MQTT, simplifying system integration.

- **Data reduction**

Aggregates, compresses, or down-samples data to reduce bandwidth usage while retaining critical context.

- **Local contextualization**

Enriches data with metadata such as timestamps, equipment IDs, batch numbers, or environmental conditions.

The result is structured, high-quality data that SCADA systems—and AI models—can consume far more efficiently.

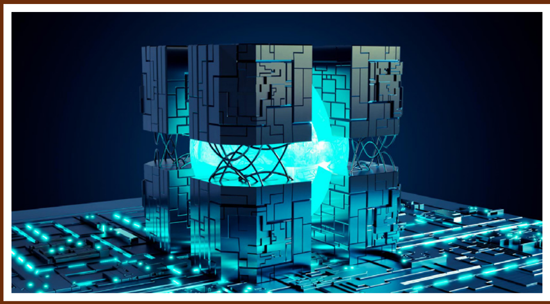
Latency-Free Control Assistance

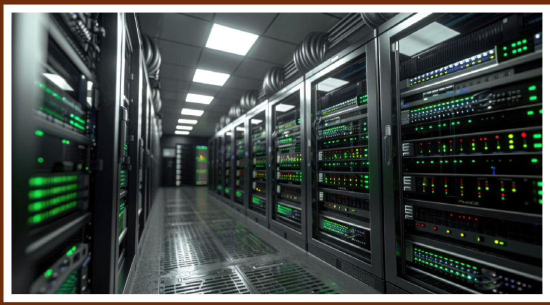
When milliseconds matter, cloud-based control is not viable. Even SCADA systems, while fast, cannot provide instantaneous feedback at microsecond levels.

Edge computing introduces latency-free control assistance, complementing PLC control loops rather than replacing them. Edge systems can:

- Perform real-time decision support using advanced algorithms
- Recommend optimized setpoints or control parameters to PLCs
- Dynamically assist with PID tuning based on live process behavior
- React instantly to anomalies, preventing damage or unsafe conditions
- Enable collaborative behavior between multiple PLCs without SCADA intervention

PLCs retain deterministic control authority, while edge systems enhance them with fast, intelligent insights.





Predictive Maintenance and Anomaly Detection: A Natural Fit

One of the most compelling applications of edge computing is predictive maintenance.

With continuous local analytics, edge devices enable:

- Real-time machine health assessment using vibration, temperature, sound, and electrical signatures
- Immediate anomaly detection—seconds instead of minutes or hours
- Early identification of bearing wear, misalignment, cavitation, and thermal drift
- On-site model refinement based on each machine's unique operating profile
- Reduced unplanned downtime and proactive maintenance scheduling

Edge-based predictive maintenance combines speed, intelligence, and autonomy, safeguarding critical assets while maximizing availability.

Challenges and Future Considerations

Increased System Complexity

Clear architectural boundaries are required to ensure edge analytics complement PLC control and SCADA supervision without conflict.

Lifecycle Management

Edge platforms follow faster IT-style update cycles. Managing operating systems, applications, and AI models across distributed devices requires centralized governance.

Cyber security and Network Segmentation

Edge devices often bridge OT and IT networks, increasing attack surfaces. Compliance with standards such as IEC 62443 is essential.

Skills Gap

Successful deployment requires expertise across automation, networking, cybersecurity, and data science—skills that are often siloed within organizations.

Standardization and Vendor Lock-In

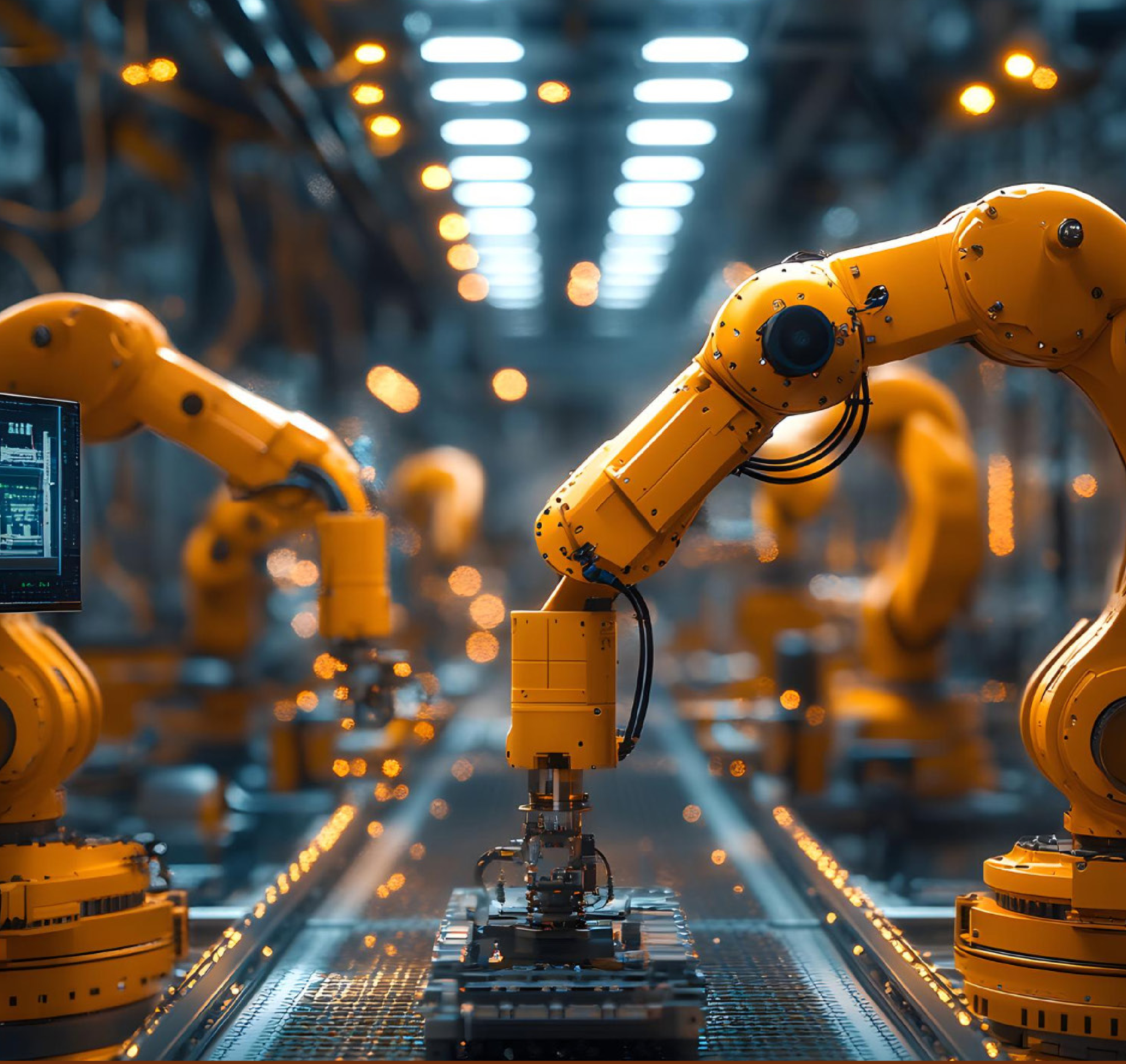
The edge ecosystem is still evolving. Open standards are critical to avoid interoperability issues and long-term vendor dependency.

Reliability and Environmental Constraints

Industrial edge hardware must withstand harsh conditions, meet uptime expectations, and fail safely—just like PLC systems.

Trust and Governance of AI

AI-driven insights must be transparent, validated, and auditable, with clear human oversight and accountability.



Conclusion: The Industrial Stack Now Includes an Edge Layer

As factories evolve into intelligent, connected ecosystems, the traditional PLC–SCADA architecture is expanding. Edge computing has become a critical middle layer that:

- Cleans and structures PLC data
- Executes AI models at the source
- Enables ultra-low-latency decision support
- Powers predictive maintenance and anomaly detection

By reducing latency, improving reliability, and embedding intelligence closer to machines, edge computing is no longer optional—it is becoming foundational to modern industrial automation.

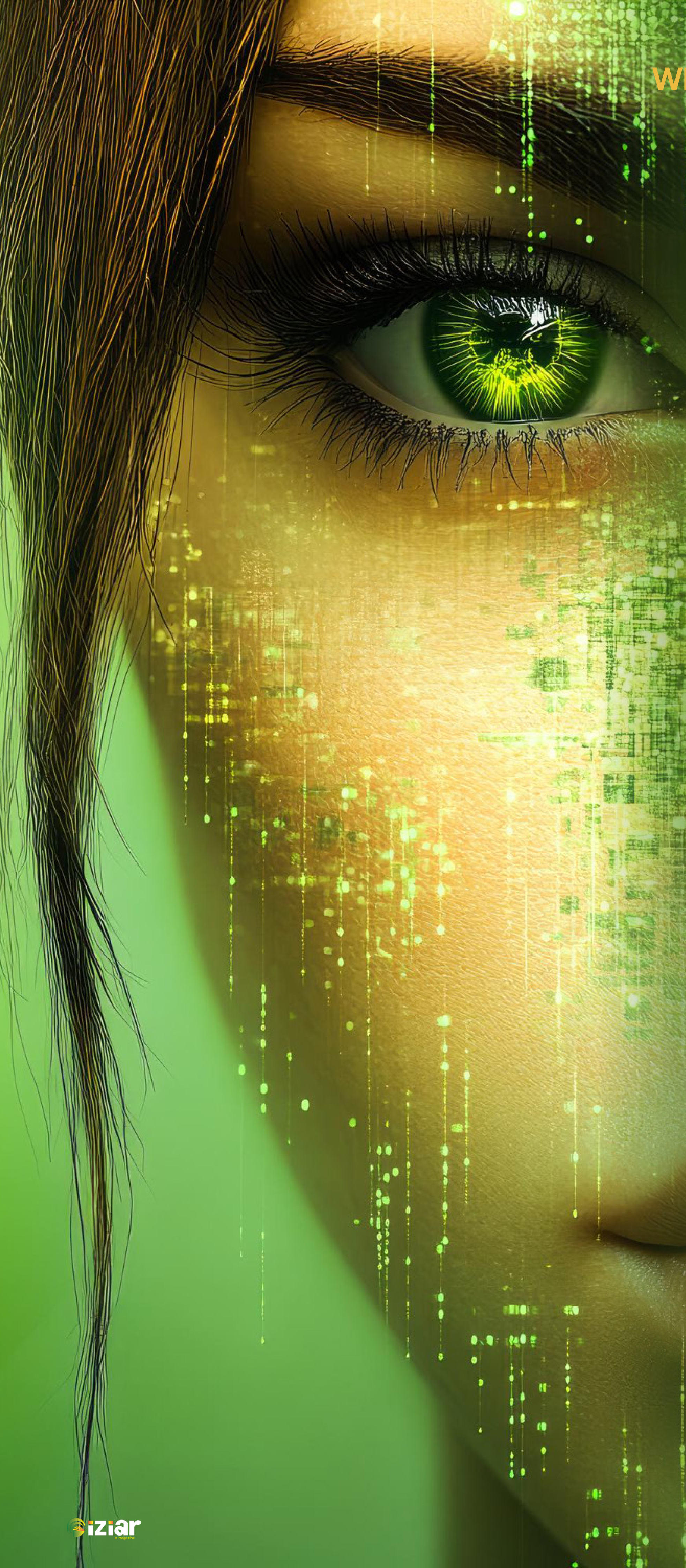
Next - Generation Software Testing Using Generative AI

Ravitha Radhakrishnan
Software Tester
Kochi

Detail-oriented Software Tester with a Postgraduate degree in Electronics and hands-on experience through internships in both Manual and Automation Testing. Skilled in identifying, analyzing, and resolving defects to ensure high-quality software delivery. Experienced in applying diverse testing methodologies to validate functionality, performance, and usability. Committed to ensuring seamless user experiences by detecting and fixing bugs before release.

The rapid evolution of modern software applications has significantly increased expectations around speed, quality, and reliability. Organizations today release software more frequently than ever before, driven by Agile methodologies, DevOps practices, and continuous integration and continuous delivery (CI/CD) pipelines. While these approaches improve responsiveness to market demands, they also place enormous pressure on traditional software testing processes. Manual testing and conventional automation techniques often struggle to keep pace with frequent requirement changes, complex system architectures, and tight release schedules.

In this context, Generative Artificial Intelligence (Generative AI) has emerged as a transformative force in software testing. By leveraging advanced machine learning models and natural language processing (NLP), Generative AI introduces smarter, faster, and more adaptive testing approaches. It enhances how test cases are designed, executed, maintained, and analyzed, enabling quality assurance teams to deliver high-quality software at speed.



What is Generative AI?

Generative AI is a subset of artificial intelligence focused on creating new content based on patterns learned from large volumes of existing data. Unlike traditional AI systems that mainly classify or predict outcomes, Generative AI can produce original outputs such as text, code, images, test data, and even complete workflows. Popular tools developed by organizations like OpenAI—such as ChatGPT—demonstrate how AI can understand human language, reason over complex inputs, and generate meaningful, context-aware responses.

In software testing, Generative AI is applied to automate and enhance multiple aspects of the testing lifecycle. It can generate test cases from requirements, create automation scripts from natural language descriptions, synthesize realistic test data, and provide intelligent insights into software quality. This makes testing more proactive, data-driven, and scalable.

Role of Generative AI in Software Testing

1. Test Case Generation

One of the most impactful applications of Generative AI is automated test case generation. By analyzing software requirements, user stories, acceptance criteria, and design documents, AI models can automatically create comprehensive test cases. These include functional test cases that validate expected behavior, as well as negative and edge-case scenarios that test system robustness.

Generative AI can also build regression test suites that evolve alongside the application. This significantly reduces the time and effort spent on manual test design while improving overall test coverage.

2. Test Automation Script Creation

Generative AI simplifies test automation by converting natural language instructions into executable automation scripts. Testers can describe test scenarios in plain English, and AI tools can generate scripts for popular automation frameworks such as Selenium, Playwright, and Cypress.

This capability lowers the entry barrier for automation, allowing testers with limited programming expertise to contribute effectively. It also accelerates automation adoption and reduces dependency on specialized automation engineers.

3. Test Data Generation

High-quality test data is critical for validating real-world scenarios, but creating and maintaining such data manually is often challenging. Generative AI addresses this by automatically producing large volumes of realistic and diverse test data.

It can generate boundary value data, stress test data, and negative datasets while also supporting data masking and anonymization to meet security and privacy requirements. This is particularly valuable for performance testing, security testing, and compliance-driven environments.

4. Defect Prediction and Analysis

By analyzing historical defect reports, source code changes, and test execution logs, Generative AI can identify patterns associated with failures. Based on this analysis, it can predict high-risk areas within an application and suggest where testing efforts should be focused.

This predictive capability enables smarter test prioritization, reduces defect leakage into production, and improves overall software quality.

5. Self-Healing Automation

Test automation scripts often fail due to minor user interface changes, such as updated element locators or layout modifications. Generative AI introduces self-healing mechanisms that automatically adapt test scripts to such changes.

By understanding application behavior and UI structure, AI-enabled tools can update locators or adjust test flows without human intervention, significantly reducing test maintenance effort.

Benefits of Generative AI in Software Testing

The adoption of Generative AI in testing delivers multiple benefits. It accelerates test creation and execution, improves test coverage across functional and non-functional areas, and reduces manual effort and overall testing costs.

Additionally, it enables early identification of defects, supports continuous testing in Agile and CI/CD pipelines, and enhances collaboration between development and testing teams. As a result, organizations can achieve faster releases without compromising on quality.

Real-Time Example

Consider an e-commerce application with login and checkout functionalities. Generative AI can analyze the requirements for these modules and automatically generate functional, negative, and security test cases. Based on historical defect data, the AI may identify the checkout module as high-risk and prioritize it for intensive testing. This targeted approach improves defect detection and ensures a smoother user experience.

Future Scope

The future of Generative AI in software testing is highly promising. Emerging trends include fully autonomous testing systems, AI-driven quality dashboards, and natural language-based test automation. Predictive analytics will enable teams to assess release readiness and quality risks in advance.

As these capabilities mature, testers will increasingly transition into roles focused on test strategy, quality analysis, and AI supervision rather than repetitive manual execution.

Conclusion

Generative AI is reshaping software testing by making it more intelligent, efficient, and adaptive. Rather than replacing human testers, it empowers them to focus on critical thinking, business validation, and user experience. As software systems continue to grow in complexity and scale, Generative AI will play a vital role in delivering high-quality, reliable, and future-ready applications.

THANKS

Expert Panels

Ajith Surendran | Rakesh K C | Jomesh Jose | Vishnu

Magazine Editor

D A Anand

Content Editing

Silsa Shaji | Ananda Sherin | Chandana P | Thana Anjana
Manu Mahadevan | Madhu Manas Pradeep | Paul Manuel
Ravitha Radhakrishnan

Design

Merin Sujith M R

Editing

D A Anand

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+91 9846 770 771