Samuel M. Karumba

GitHub | LinkedIn | Google Scholar | karumba66@gmail.com | ORCID

Summary

Research engineer and AI systems architect with a record of building scalable, intelligent platforms across IBM Research, CSIRO Data61, and UNSW. Experienced in designing Python-based microservices, AI-driven analytics frameworks, and secure distributed systems for enterprise and research applications. Skilled in developing containerized and cloud-native architectures using Docker, Kubernetes, and Azure, integrating LLM and agentic AI workflows, and automating DevOps pipelines with GitHub Actions. Proven ability to lead cross-disciplinary engineering teams, bridging data science, software development, and applied research to deliver production-grade, AI-enabled systems that translate innovation into measurable impact.

Education

May 2019 – Feb 2024 **PhD** Computer Science & Engineering at **University of New South Wales (UNSW)**, Sydney, Australia
UNSW Scientia Scholarship recipient (highly competitive award for top-tier doctoral students)
Supervisors: Prof. Salil S. Kanhere (UNSW), Prof. Raja Jurdak (QUT), Dr. Subbu Sethuvenkatraman (CSIRO)
Thesis: "Blockchain-based Decentralized Energy Systems: Advancing Scalability, Security, Privacy, and Interoperability."
Research focus: Distributed systems architectures and ubiquitous computing frameworks with specialized applications in distributed energy resource management and smart grid technologies

Sep 2013 – Jul 2017 **MSc** Mobile Telecommunication Innovation & Development (**Safaricom Academy**) at **Strathmore University**, Nairobi, Kenya
Joint industry–academia program by Safaricom PLC and Strathmore University focused on mobile systems innovation, telecommunications architecture, and applied R&D.
Safaricom Academy Scholarship recipient (industry-backed full scholarship)
Supervisor: Dr. Vitalis Gavole Ozianyi
Dissertation: "Smart education: an event framework for cognitive blended learning."
Research focus: Mobile telecommunications systems, software innovation, and cognitive learning frameworks
GPA: 3.56/4.00

Sep 2009 – Dec 2012 **BSc** Computer Science at **Moi University**, Eldoret, Kenya
Second Class Honours — Upper Division
Capstone Project: Developed a number plate recognition system for city council and parking lot management using artificial intelligence and computer vision techniques.

Work Experience

Research & Innovation Consultant, Secure Decentralized Systems Jan 2025 – Present

- Lead design and development of Python-based fintech infrastructure for cross-border payments using Layer-2 protocols and API gateways, integrating smart contract verification and compliance modules.
- Architect and deploy CI/CD pipelines with Docker and GitHub Actions for blockchain and data analytics platforms, enabling automated testing and secure containerized deployment.
- Build analytics frameworks in Python and SQL to support performance monitoring, financial modeling, and decision support for virtual power plant operations.
- Conduct technical due diligence and scalability audits on distributed ledger systems, evaluating transaction throughput, reliability, and regulatory alignment.
- Collaborate with engineering teams across three fintech ventures to move prototypes into production, improving data processing efficiency and reducing deployment times by 40%.

Postdoctoral Research Engineer, CSIRO Data61, Sydney Dec 2023 – Dec 2024

- Led the engineering of AI-driven cybersecurity models for distributed energy resources as part of the CAESER program, delivering modular APIs for smart inverter security used by Australian utilities.
- Developed and containerized Python microservices for risk taxonomy, anomaly detection, and automated compliance verification, deployed through Azure pipelines.
- Published and deployed threat intelligence models integrating LLM-based classifiers for real-time vulnerability assessment and incident reporting.
- Collaborated with multidisciplinary teams to translate research into production tools, streamlining data ingestion and improving system responsiveness by 30%.

PhD Researcher, UNSW & CSIRO Energy Business Unit May 2019 – Jul 2023

- Designed and implemented blockchain and AI-enabled frameworks in Python (**HARB**, **PlexiChain**, **CypherChain**, **BAILIF**) to enhance scalability, interoperability, and privacy in decentralized energy trading.
- Deployed distributed ledger and analytics models within CSIRO's Data Clearing House (200+ smart buildings, 5 MW capacity), enabling privacy-preserving data exchange and real-time energy forecasting.
- Containerized blockchain and ML models with Docker, enabling reproducible experiments and automated performance testing via CI/CD pipelines.
- Published peer-reviewed research in IEEE IoT-J, IEEE ICBC, and ACM e-Energy, translating research into operational prototypes and open-source implementations.

Research Software Engineer, IBM Research Africa, Nairobi Sep 2014 – May 2019

- Led Python and Java-based backend development for IBM's global blockchain platform **TradeLens**, improving API synchronization latency by 25% and supporting integration across 600+ ports.
- Developed and maintained DevOps workflows using Jenkins and Docker for CI/CD, automated testing, and cloud deployment across global teams in Nairobi, Zurich, and India.
- Built AI-powered optimization tools for agricultural logistics, increasing field efficiency by 20% and resulting in U.S. Patent US 11,497,156 B2.
- Designed and deployed national-scale education data systems for the School Census Hub project, integrating mobile data ingestion and analytics dashboards using React and Python.
- Filed three U.S. patents across distributed systems, medtech, and data analytics, demonstrating consistent translation from R&D to production and IP.

Projects

AI and Cybersecurity Systems

1. **CAESER — Cybersecurity of Consumer Energy Resources** (CSIRO, UNSW, ECU, ACM e-Energy '24)
   Led design and validation of scalable cybersecurity frameworks for smart-grid systems. Engineered a Python-based risk-assessment pipeline that improved threat detection accuracy by 30%. Delivered APIs adopted by Australian utilities. [Python, Docker, Azure, MLflow]
2. **Data Clearing House (CSIRO)**
   Architected blockchain and analytics modules within a $2 M+ platform deployed across 200 smart buildings (5 MW flexible capacity). Delivered privacy-preserving telemetry modules and real-time energy-transaction dashboards. [Python, React, Docker, AWS IoT]

Blockchain and Fintech Platforms

3. **HARB — Hypergraph-Based Adaptive Consortium Blockchain** (IEEE IoT-J Q1)
   Developed a hypergraph-based clustering algorithm for distributed ledgers, improving throughput by 30% and latency by 25%. [Python, Go, Kubernetes]
4. **PlexiChain — Secure Flexibility Aggregation Framework**
   Built a blockchain-based marketplace for flexibility trading using a double-auction smart-contract and behavioural-incentive mechanisms, improving market efficiency by 40%. [Solidity, Python, Flask, Web3]
5. **CypherChain — Privacy-Preserving Data Aggregation** (IEEE ICBC '24)
   Engineered privacy-preserving aggregation protocols using zero-knowledge proofs (ZKP) and secure multiparty computation (SMPC), reducing communication overhead by 40%. [Python, Go, Cryptography Libraries]
6. **BAILIF — Blockchain Agnostic Interoperability Framework** (IEEE ICBC '23)
   Led a cross-disciplinary team designing decentralized cross-chain attestation protocols. Achieved 666 transactions per second and enabled interoperability between Hyperledger and Ethereum networks. [Go, Python, gRPC, Docker]

Applied AI and Infrastructure Systems

7. **EnergiPay — Off-Chain Payment Channels for Energy Trading** (ACM e-Energy '24)
   Co-developed a Layer-2 off-chain payment-channel protocol enabling near-instant settlement between energy prosumers. Reduced transaction fees by 60% compared to on-chain equivalents. [Python, Solidity, FastAPI]
8. **Carbon Certification & Development Initiative (CCDI, UNSW) ***
   Built a blockchain-backed carbon-credit registry architecture integrating oracle-based emission verification. Supported three industry partners' adoption strategies and contributed to securing $500 k in follow-on research funding. [Python, Node.js, PostgreSQL]
9. **TradeLens — Global Supply Chain Blockchain Platform** (IBM Blockchain)
   Served as backend engineer for IBM's blockchain system, contributing to smart-contract modules and data pipelines supporting 100 000+ users across 600 ports. Improved cargo visibility and auditability by 35%. [Python, Java, Jenkins, Docker]

Skills

AI Systems & Python Engineering

- **Python Architecture & Development:** Expert in Python for AI, data, and backend engineering; design of containerized applications using Docker and Kubernetes; integration of microservices and API gateways (REST, gRPC); implementation of strongly-typed, efficient, and maintainable Python codebases.
- **Generative & Agentic AI Systems:** Development of LLM-based and agentic AI frameworks (LangChain, Azure OpenAI); orchestration of intelligent agents and AI pipelines for enterprise-grade applications; embedding NLP and multimodal models into production services.
- **DevOps & Cloud Infrastructure:** Continuous integration and deployment (GitHub Actions, Azure DevOps, Jenkins); cloud orchestration across Azure, AWS, and GCP; implementation of monitoring, automation, and security compliance workflows.

Data Science, Machine Learning & Intelligence

- **Data Engineering & Analytics:** Data ingestion and modeling using SQL, PowerBI, Databricks, and Snowflake; telemetry integration from distributed systems and IoT networks; data-driven performance and risk analysis.
- **Machine Learning & Statistical Modeling:** Development and deployment of predictive models with pandas, scikit-learn, and PyTorch; experience in anomaly detection, time-series forecasting, and model interpretability.
- **Research-driven AI Development:** Application of machine learning to secure energy systems and fintech data flows; experimental validation and real-world deployment of research-grade algorithms.

Cybersecurity, Blockchain & Privacy Engineering

- **Blockchain Systems:** Design and audit of smart contracts (Certora, Slither, MythX, Echidna); Hyperledger Fabric and Ethereum framework development; architecture of interoperable, scalable blockchain infrastructures.
- **Applied Cryptography:** Experience with zero-knowledge proofs (ZKP), homomorphic encryption (HE), and secure multiparty computation (SMPC); analysis of consensus protocols and distributed trust mechanisms.
- **Secure Fintech & Compliance:** Design of off-chain payment channels, tokenized assets, and fraud detection systems; compliance with PCI-DSS, ISO 27001, and GDPR standards.

Software, Systems & Mobile Innovation

- **Systems Architecture:** Design of fault-tolerant, scalable, and ubiquitous computing systems; integration of context-aware computing frameworks and edge-cloud coordination (AWS IoT, GCP Edge).
- **Telecommunication & Mobile Systems:** Expertise in mobile network architecture, operator APIs (SMS, USSD, M-Pesa gateways), and cross-platform mobile development (Android, iOS); innovation management and incubation from Safaricom Academy training.

Leadership, Research & Collaboration

- **Technical Leadership:** Lead cross-functional R&D and software teams across IBM, UNSW, and CSIRO; architected research-to-production transitions and guided large-scale data and AI projects.
- **Collaboration & Mentorship:** Supervised postgraduate and undergraduate research projects; provided mentorship and technical guidance to engineering teams in distributed systems and blockchain security.

Research Outputs

Conference Papers

[1] X. Hui, **S. Karumba**, S. C.-K. Chau, and M. Ahmed, "Destabilizing power grid and energy market by cyberattacks on smart inverters," in *Proceedings of the 16th ACM International Conference on Future and Sustainable Energy Systems (e-Energy '25)*, **Cited by: 1** — Conference Ranking: A-rank (CORE 2023), Association for Computing Machinery, 2025.

[2] S. C.-K. Chau, N. Wang, and **S. Karumba**, "Energipay: Off-chain payment channel for blockchain-enabled peer-to-peer energy trading," in *Proceedings of the 15th ACM International Conference on Future and Sustainable Energy Systems (e-Energy '24)*, **Cited by: 3** — Conference Ranking: A-rank (CORE 2023), Singapore, Singapore: Association for Computing Machinery, 2024, ISBN: 979-8-4007-0480-2. DOI: 10.1145/3632775.3661985.

[3] **S. Karumba**, S. C.-K. Chau, H. Pearce, M. Ahmed, and H. Janicke, "Systematic study of cybersecurity threats for smart inverters," in *Proceedings of the 15th ACM International Conference on Future and Sustainable Energy Systems (e-Energy '24)*, **Cited by: 3** — Conference Ranking: A-rank (CORE 2023), Singapore, Singapore: Association for Computing Machinery, 2024, pp. 669–675, ISBN: 979-8-4007-0480-2. DOI: 10.1145/3632775.3661994.

[4] **S. Karumba**, V. Dedeoglu, R. Jurdak, and S. S. Kanhere, "Cypherchain: A privacy-preserving data aggregation framework for blockchain-based dr programs," in *2024 IEEE International Conference on Blockchain and Cryptocurrency (ICBC)*, Conference Ranking: SJR: 0.340, Impact Factor: 3.04, IEEE, 2024.

[5] **S. Karumba**, R. Jurdak, S. S. Kanhere, and S. Sethuvenkatraman, "Bailif: A blockchain agnostic interoperability framework," in *2023 IEEE International Conference on Blockchain and Cryptocurrency (ICBC)*, **Cited by: 15** — Conference Ranking: SJR: 0.340, Impact Factor: 3.04, h-index: 14, IEEE, 2023, pp. 1–9. DOI: 10.1109/ICBC56567.2023.10174967.

[6] **S. Karumba**, S. S. Kanhere, and R. Jurdak, "A relational network framework for interoperability in distributed energy trading," in *2020 IEEE International Conference on Blockchain and Cryptocurrency (ICBC)*, **Cited by: 2** — Conference Ranking: SJR: 0.340, Impact Factor: 3.04, h-index: 14, IEEE, 2020, pp. 1–3. DOI: 10.1109/ICBC48266.2020.9169462.

[7] N. Bore, **S. Karumba**, J. Mutahi, *et al.*, "Towards blockchain-enabled school information hub," in *Proceedings of the Ninth International Conference on Information and Communication Technologies and Development (ICTD '17)*, **Cited by: 111** — Conference Ranking: C-rank (CORE 2018), Lahore, Pakistan: Association for Computing Machinery, 2017. DOI: 10.1145/3136560.3136584.

[8] A. Kinai, J. Mutahi, N. Bore, **S. Karumba**, *et al.*, "Deploying large scale school census hub: An experience report," in *2017 IEEE/ACM 39th International Conference on Software Engineering: Software Engineering in Society Track (ICSE-SEIS)*, **Cited by: 3** — Conference Ranking: A*-rank (CORE 2023), IEEE, 2017, pp. 47–56. DOI: 10.1109/ICSE-SEIS.2017.7.

[9] D. Kaguma, **S. Karumba**, A. Walcott-Bryant, and K. Weldemariam, "Towards cooperative content downloading for resource-constrained mobile devices," in *Proceedings of the International Conference on Mobile Software Engineering and Systems (MOBILESoft '16)*, **Cited by: 1**, Austin, TX, USA: Association for Computing Machinery, 2016, pp. 189–198. DOI: 10.1145/2897073.2897083.

Journal Articles

[10] **S. Karumba**, S. Sethuvenkatraman, V. Dedeoglu, R. Jurdak, and S. S. Kanhere, "Barriers to blockchain-based decentralised energy trading: A systematic review," *International Journal of Sustainable Energy*, vol. 42, no. 1, pp. 41–71, Feb. 2023, **Cited by: 49** — **Q2 in Energy** — Impact Factor: 3.5 — h-index: 42. DOI: 10.1080/14786451.2023.2171417.

[11] **S. Karumba**, S. S. Kanhere, R. Jurdak, and S. Sethuvenkatraman, "Harb: A hypergraph-based adaptive consortium blockchain for decentralized energy trading," *IEEE Internet of Things Journal*, vol. 9, no. 16, pp. 14 216–14 227, 2022, **Cited by: 34** — **Q1 in Computer Networks** — Impact Factor: 8.2 — CiteScore: 17.6 — h-index: 179. DOI: 10.1109/JIOT.2020.3022045.

[12] A. Dorri, F. Luo, **S. Karumba**, S. S. Kanhere, R. Jurdak, and Z. Y. Dong, "Temporary immutability: A removable blockchain solution for prosumer-side energy trading," *Journal of Network and Computer Applications*, vol. 180, p. 103 018, 2021, **Cited by: 28** — **Q1 in Computer Networks** — Impact Factor: 7.7 — CiteScore: 21.5 — h-index: 141. DOI: 10.1016/j.jnca.2021.103018.

Patents

[13] J. Mutahi, D. W. Kaguma, **S. M. Karumba**, *et al.*, "Farm cultivation quality," Patent US11497156B2, Nov. 2022. [Online]. Available: https://patents.google.com/patent/US11497156B2/en.

[14] **S. M. Karumba**, C. A. Pickover, and K. Weldemariam, "Tracking items used for providing medical services," Patent Application US20180189449A1, Jul. 2018. [Online]. Available: https://patents.google.com/patent/US20180189449A1/en.

[15] D. W. Kaguma, **S. Karumba**, and K. Weldemariam, "Cooperative download among low-end devices under resource-constrained environment," Patent US9961139B2, May 2018. [Online]. Available: https://patents.google.com/patent/US9961139B2/en.

Theses & Dissertations

[16] **S. Karumba**, "Blockchain-based decentralized energy systems: Advancing scalability, security, privacy, and interoperability," Supervisor: Prof. S. Kanhere, Prof. R. Jurdak — **UNSW Scientia Scholarship Recipient**, PhD Thesis, University of New South Wales, 2023.

[17] **S. M. Karumba**, "Smart education: An event framework for cognitive blended learning," Safaricom Academy Scholarship Recipient, MSc Thesis, Strathmore University, 2017.

Technical Reports & Software Frameworks

[18] **S. Karumba**, S. S. Kanhere, R. Jurdak, and S. Sethuvenkatraman, *Plexichain: A secure blockchain-based flexibility aggregator framework*, arXiv preprint arXiv:2212.09064, **Cited by: 1**, 2022. arXiv: 2212.09064 [cs.CR]. [Online]. Available: https://arxiv.org/abs/2212.09064.

[19] X. Hui, **S. Karumba**, S. C.-K. Chau, and M. Ahmed, *Destabilizing power grid and energy market by cyberattacks on smart inverters (extended version)*, arXiv preprint arXiv:2505.14175, Extended version of the paper published in ACM e-Energy '25, 2025. arXiv: 2505.14175 [cs.CR]. [Online]. Available: https://arxiv.org/abs/2505.14175.

Book Chapters

[20] **S. Karumba**, V. Dedeoglu, A. Dorri, R. Jurdak, and S. S. Kanhere, "Utilizing blockchain as a citizen-utility for future smart grids," in *Wireless Blockchain: Principles, Technologies, and Applications*, **Cited by: 4**, John Wiley & Sons, 2021, pp. 201–224. DOI: 10.1002/9781119790839.ch9.

Presentations & Invited Talks

[21] **S. Karumba**, *Cybersecurity threats for smart inverters*, Presented at ACM e-Energy '24, Singapore, 2024. [Online]. Available: https://dl.acm.org/doi/10.1145/3632775.3661994.

[22] **S. Karumba**, *Blockchain interoperability for energy markets*, Presented at IEEE ICBC '23, Dubai, 2023. [Online]. Available: https://doi.org/10.1109/ICBC56567.2023.10174967.

[23] **S. Karumba**, *Privacy-preserving computation in energy trading*, UNSW–CSIRO Seminar Series, 2023. [Online]. Available: https://research.csiro.au/dch/.

Research Grants & Funding

2023 – 2024 **CAESER: Cybersecurity of Consumer Energy Resources** — *National Program*
CSIRO Data61, UNSW, Edith Cowan University
Role: Postdoctoral Research Engineer
PI: Dr. Sid Chi-Kin Chau, Dr. Sharif Abuadbba

2020 – 2024 **CSIRO PhD Top-up Scholarship** — *AUD $40,000*
CSIRO Data61
Role: PhD Scholar
Award: $10,000 per annum + $5,000 development budget

2019 – 2024 **UNSW Scientia PhD Scholarship** — *AUD $205,000+*
University of New South Wales
Role: Principal Recipient
Award: full tuition + $41,209 stipend per annum (indexed) + $10,000 development fund per annum

2015 – 2018 **Educational Data Analytics Initiative** — *USAID/IBM USD $100M Project Lucy*
IBM Research Africa, RTI International, Mombasa County
Role: Co-Investigator
Scope: 100+ schools blockchain data systems deployment

2023 **ACE-SIP Summer School Travel Award** — *Professional Development*
Algorand Centre of Excellence, Monash University
Role: Research Engineer
Program: Sustainability Informatics for the Pacific

Scholarships & Awards

03 Feb 2023 **ACE Summer School Stipend** — Monash Univ. (Melbourne). *Stipend support for participation in the African Cybersecurity and Energy Systems Summer School.*

01 Apr 2020 **CSIRO PhD Top-up Scholarship** — UNSW/CSIRO Energy (Sydney). *Research scholarship for doctoral work on secure distributed energy systems.*

03 Aug 2018 **UNSW Scientia Scholarship** — Ph.D., UNSW (Sydney). *Flagship doctoral award for exceptional research potential across disciplines.*

22 Aug 2013 **Safaricom Academy Scholarship** — M.Sc. Mobile Telecommunication & Innovation, Strathmore Univ. (Nairobi). *Industry-backed full scholarship delivered under the Safaricom–Strathmore partnership for advanced mobile innovation training.*

Referees

Prof. Salil S. Kanhere **Professor, UNSW, Australia**

Relation: Primary PhD supervisor (2019-2024)
Contact: available upon request
Research Areas: IoT, Blockchain, Cyber-Physical Systems, Cybersecurity, Applied ML

Prof. Raja Jurdak **Professor, QUT, Australia**

Relation: PhD co-supervisor (2019-2024), Director of Trusted Networks Lab
Contact: available upon request
Research Areas: IoT, Blockchain, Distributed Systems, Energy Systems

Dr. Charity Wayua **Director, IBM Research Africa**

Relation: Research manager at IBM Research Africa (2017-2019)
Contact: available upon request
Research Areas: Human-Computer Interaction, Digital Inclusion, ICT4D

Dr. Sid Chi-Kin Chau **Principal Research Scientist, CSIRO Data61**

Relation: Research manager at CSIRO Data61 (2023-2024)
Contact: available upon request
Research Areas: Cybersecurity for Energy Systems, Blockchain, IoT Security