Samuel M. Karumba

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Professional Summary

Senior Research Engineer and Technical Lead specializing in blockchain systems, cryptographic infrastructure, and AI-integrated data platforms. Experienced in designing and deploying permissioned ledgers using Hyperledger Fabric and private Ethereum networks across energy, education, and fintech domains. Skilled in architecting secure, containerized microservice environments and translating advanced research into scalable production systems. At IBM Research Africa and CSIRO Data61, I led the development of several enterprise-grade blockchain frameworks, such as HARB, BAILIF, and CypherChain (detailed in the Projects section), that integrated zero-knowledge proofs, consensus optimization, and privacy-preserving analytics. Brings deep technical capability in Python, Go, Rust, and Solidity with strong DevOps practice in Docker, Kubernetes, and CI/CD automation. Committed to advancing trustworthy AI and data-integrity systems for regulated sectors, including healthcare, energy, and digital finance, enabling verifiable AI and secure data collaboration in next-generation digital ecosystems.

Education

May 2019 – Feb 2024 **PhD** Computer Science & Engineering at **University of New South Wales (UNSW)**, Sydney, Australia
UNSW Scientia Scholarship recipient — a flagship award for top-tier doctoral researchers.
Jointly conducted with the CSIRO Energy Business Unit under the Digital Energy Systems Group.
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 ledger architectures, privacy-preserving computation, and ubiquitous systems engineering with applications in smart grid and distributed energy resource (DER) management.

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 focusing on telecommunications innovation, mobile 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, event-driven architectures, and cognitive learning analytics.
GPA: 3.56/4.00

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

Experience

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

- Leading design and deployment of blockchain-based data integrity systems and verifiable AI infrastructures for fintech and energy startups across Africa and Australia.
- Architecting Hyperledger Fabric networks supporting identity management, permissioned data exchange, and smart contract governance for compliance-aware applications.
- Developing modular data pipelines integrating blockchain and analytics for AI explainability and traceability in distributed systems.
- Conducting scalability, performance, and cryptographic audits for early-stage blockchain ventures, ensuring resilience and regulatory compliance.
- Delivering DevOps pipelines for blockchain platforms, integrating containerized testing, monitoring, and CI/CD automation using Docker, Kubernetes, and GitHub Actions.

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

- Led engineering of cybersecurity and blockchain-based assurance frameworks within the CAESER program (Cybersecurity of Consumer Energy Resources).
- Designed permissioned blockchain prototypes for data provenance and device attestation across smart inverters and distributed energy systems.
- Integrated AI-driven anomaly detection and risk classification models for grid-edge systems, improving incident detection precision by 30%.
- Authored peer-reviewed publications translating research into operational frameworks adopted by Australian utilities and policy bodies.

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

- Designed and implemented blockchain frameworks (HARB, BAILIF, CypherChain, PlexiChain) focused on scalability, interoperability, and privacy-preserving analytics for distributed energy markets.
- Developed cryptographic aggregation models and smart-contract protocols validated across 200+ smart buildings through CSIRO's Data Clearing House (5 MW flexible capacity).
- Published multiple high-impact outputs in IEEE IoT-J, IEEE ICBC, and ACM e-Energy on blockchain security, data integrity, and cyber-physical energy systems.
- Supervised student researchers and coordinated research translation from prototype to pilot deployment with national stakeholders.

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

- Co-architected blockchain systems for IBM's global research portfolio, including **TradeLens**—a supply-chain platform serving 100,000+ users across 600 ports.
- Led development of mobile and backend systems integrating event frameworks, sensor analytics, and learning models, extending MSc research from Safaricom Academy into enterprise-scale projects.
- Built blockchain prototypes for education, agriculture, and logistics sectors; achieved measurable operational impact (up to 25% improvement in data synchronization latency).
- Filed multiple patents (US9961139B2, US20180189449A1, US11497156B2) on blockchain, IoT, and medical data systems; contributed to IP strategy and technical documentation for IBM's patent portfolio.

Projects

AI-Driven and Blockchain-Enabled Systems

1. **IBM Research Africa — Disease Surveillance Decision-Support System** (IBM Research Africa; 2017)
   Contributed to the design and field deployment of a web-based decision-support platform for district-level disease surveillance in Sierra Leone. Developed data integration pipelines and visualization modules to enable early outbreak detection and resource coordination in post-Ebola contexts. Supported system architecture, analytics, and field validation with health agencies and humanitarian partners. [Tech: Python, IBM Cloud, Flask, SQL, Data Visualization]

2. **TradeLens — Global Supply Chain Blockchain Platform** (IBM & Maersk; 2018)
   Contributed as a backend engineer to an open, blockchain-enabled digital logistics platform co-developed by IBM and Maersk. Built data-ingestion and smart-contract modules that enabled multi-party shipment event visibility and document sharing across carriers, ports, and customs. [Tech: Java, Python, Jenkins, Docker, Kafka]

3. **Data Clearing House (CSIRO) — Distributed Energy Data Exchange**
   Architected blockchain and analytics components within a $2M+ multi-institutional platform deployed across 200+ smart buildings (5 MW flexible capacity). Implemented privacy-preserving telemetry pipelines and real-time energy transaction dashboards adopted by utilities. [Tech: Python, React, Docker, AWS IoT, SQL]

4. **CAESER — Cybersecurity of Consumer Energy Resources** (CSIRO, UNSW, ECU; ACM e-Energy '24)
   Led design and validation of scalable cybersecurity and blockchain assurance frameworks for smart-grid systems. Developed a security framework that informed national security standards for distributed energy devices. [Tech: Python, Docker, MLflow, Azure, Flask APIs]

Blockchain Research Frameworks

5. **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 peer-to-peer settlement among energy prosumers. Reduced transaction fees by 60% compared to on-chain models and enhanced scalability for micro-POS systems. [Tech: Python, Solidity, FastAPI, Kafka, SQLite]

6. **HARB — Hypergraph-Based Adaptive Consortium Blockchain** (IEEE IoT-J, Q1)
   Designed and evaluated a hypergraph-based consensus clustering algorithm that improved blockchain throughput by 30% and reduced latency by 25%. Demonstrated feasibility on a live energy trading testbed. [Tech: Python, Go, Kubernetes, Fabric SDK]

7. **PlexiChain — Secure Flexibility Aggregation Framework**
   Developed a blockchain-enabled marketplace for flexibility trading using double-auction smart contracts and behavioural incentive mechanisms. Improved energy market efficiency by 40% and ensured tamper-proof transactions. [Tech: Solidity, Python, Flask, Web3, PostgreSQL]

8. **CypherChain — Privacy-Preserving Data Aggregation** (IEEE ICBC '24)
   Engineered privacy-preserving aggregation protocols employing zero-knowledge proofs (ZKP) and secure multiparty computation (SMPC). Reduced communication overhead by 40% while maintaining compliance for energy demand-response programs. [Tech: Go, Cryptography Libraries, Fabric CA]

9. **BAILIF — Blockchain-Agnostic Interoperability Framework** (IEEE ICBC '23)
   Led a cross-disciplinary team to design decentralized cross-chain attestation protocols enabling interoperability between Hyperledger Fabric and Ethereum networks. Achieved 666 transactions per second with optimized notary consensus. [Tech: Go, gRPC, Python, Docker, Kubernetes]

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