

# Research Experience, Interests, and Intended Contribution

Position 2: Internet of Things and Automation — HET Systems Centre, MRU  
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## Research Vision

My research advances **reliable, portable, and secure IoT systems** spanning the edge–cloud continuum. I focus on (i) **heterogeneous deployment** across CPUs/GPUs and multiple ISAs, (ii) **lightweight runtimes** (e.g., WebAssembly) for safe, near-native execution at the edge, and (iii) **automation** for orchestration, observability, and resilience in dynamic, resource-constrained environments. At the HET Systems Centre, I will develop *automation-by-design* methods to make IoT stacks easier to deploy, verify, and adapt in real-world settings such as energy, mobility, and agriculture.

## Track Record and Experience

- **Edge/Cloud portability**  
*University of Luxembourg (SnT), ACE5G (FNR) with Proximus.* I designed cross-architecture containerization workflows and evaluated **WebAssembly (Wasm)** and **multi-arch containers** on x86\_64 and ARM64 (NVIDIA Jetson) targets. I investigated GPU acceleration, task throughput, and memory footprint, and built reproducible pipelines with containerd, k3s, and runwasi.
- **Automation and orchestration**  
Built end-to-end CI-driven experiments for cold/cached startup, image pull time, and execution latency, enabling **policy-based scheduling** (e.g., energy-, latency-, or trust-aware placement) across heterogeneous nodes.
- **IoT offloading and mobility**  
Proposed **mobility-aware task offloading** strategies in fog/edge systems (vehicular scenarios), reducing unnecessary service migrations while meeting latency budgets.
- **Applied IoT prototyping**  
Delivered an **IoT lighting system** integrating sensors, cloud backends, and Android monitoring with real-time fault detection.

## Intended Work at HET: Position 2 (IoT & Automation)

I propose a **three-year research line** (initial one-year plan below) to build an *Automation Fabric for Heterogeneous IoT (AutoHetIoT)*, a set of methods and open tooling to simplify secure deployment, runtime adaptation, and trustworthy operation of IoT applications across edge and cloud.

### Year 1 Objectives (1-year fixed term)

1. **Portable Edge Runtime Toolkit:** Hardened Wasm-based edge runtime profiles for ARM64 and RISC-V with *capability-oriented sandboxes*, deterministic resource quotas, and **zero-downtime** hot-swapping.
2. **Automation Policies & Scheduling:** Constraint-aware placement (latency, energy, carbon intensity, data locality) for containerd/k3s, with **explainable decisions** and fallbacks for degraded networks.

3. **Resilience & Observability:** Lightweight **SLO guards** (latency/throughput/ML inference accuracy) and **self-healing** actions (restart, migrate, scale-to-zero) driven by online telemetry.
4. **Security-by-Design:** Supply-chain attestations (SBOMs), signed artifacts, and per-node trust policies to **automate** secure upgrades and rollbacks.

## Methodology

- **Experiment Platforms:** AWS bare metal and on-prem ARM64 clusters (e.g., NVIDIA Jetson), with synthetic (TPC-like) and domain traces (mobility/energy).
- **Runtimes:** containerd, k3s, runwasi/Wasm, and GPU offloading where appropriate.
- **Metrics:** Startup/latency SLOs, energy per task, memory footprint, service availability, upgrade MTTR/MTBF.
- **Reproducibility:** Open repositories, containerized pipelines, and **artifact evaluation** scripts.

## Use-Case Pilots (co-designed with HET partners)

- **Smart Mobility:** On-vehicle and roadside edge nodes running Wasm microservices for perception pre-processing and incident detection, with live migration under handovers.
- **Energy Microgrids:** Forecasting/control loops at the edge with constraint-aware placement to reduce peak loads; verifiable firmware-style updates via Wasm.
- **Digital Agriculture:** Sensor fusion and anomaly detection with intermittent connectivity; local-first analytics and privacy-preserving aggregation.

## Contribution to the HET Centre

- **Interdisciplinarity:** Co-develop datasets and pilots with colleagues in CPS security, data science, and digital twins; provide the *automation layer* consumed by these workstreams.
- **Funding & Networks:** Contribute to Horizon Europe / COST / EIC proposals (IoT, Edge AI, trustworthy computing); leverage ongoing industry links (telecom, mobility, energy).
- **Education:** Develop a *Portable IoT Systems* module and supervise student projects aligned with Centre pilots; promote **open, reproducible** practices.

## 12–18 Month Milestones

- Open-source **AutoHetIoT** toolkit (runtime profiles + policy engine + SLO guards).
- Two pilot demonstrators (mobility, energy) with quantified SLO/energy improvements.
- Co-authored funding proposals and joint publications with HET collaborators.