Collaboration Notes: Dr. Alfons Laarman

Associate Professor - Formal Verification & Quantum Computing

Background Research

Leadership & Projects

1. **System Verification Lab (SVL)**
   - Leader of SVL at LIACS
   - Focus: Model checking, formal verification
   - Parallel and distributed algorithms
2. **Applied Quantum Algorithms (aQa)**
   - Co-founder of interdisciplinary initiative
   - Bridge classical and quantum computing
   - Focus on practical quantum applications
3. **Major Grants**
   - **Divide & Quantum** (€2M): Quantum algorithms for real problems
   - **BoostQA** (NWO): Bridging quantum-classical gap
   - Multiple EU consortium projects with industry

Research Areas

- **Model Checking**: Automated verification of systems
- **Quantum Computing**: Algorithms and simulation
- **Parallel Computing**: Multi-core verification
- **Decision Diagrams**: Compact representations (LIMDD)

Understanding His Work

Model Checking & Verification

Core Concept: Automatically verify that systems behave correctly

- Exhaustive exploration of all possible states
- Mathematical proof of correctness
- Tools: LTSmin model checker

Quantum Computing Focus

Key Innovation: Making quantum computing practical

- **Divide & Quantum**: Break problems into quantum-sized pieces
- **LIMDD**: Efficient simulation of quantum circuits
- **Hybrid Algorithms**: Combine classical and quantum

The Quantum-Classical Bridge

His work addresses the fundamental challenge:

- Quantum computers offer speedup but are limited
- Classical computers are mature but slower
- Solution: Hybrid approaches that use both optimally

Concrete Collaboration Ideas

Project 1: Quantum-Enhanced API Verification

Goal: Use quantum algorithms to scale jGuard verification

Technical Approach:

1. **Quantum Model Checking**:
   - Formulate API verification as SAT problem
   - Use quantum algorithms for exponential speedup
   - Apply his model counting techniques
2. **Hybrid Verification**:
   - Classical preprocessing with jGuard
   - Quantum core for hard instances
   - Classical post-processing
3. **Implementation**:
   - Extend LIMDD for API state spaces
   - Integrate with LTSmin
   - Benchmark on real APIs

Why This Matters:

- First application of quantum to API verification
- Scales jGuard to massive codebases
- Publishable in top venues (CAV, TACAS)

Project 2: Formal Verification of jGuard Specifications

Goal: Prove correctness of jGuard transformations

Technical Approach:

1. **Formal Model**:
   - Model jGuard semantics in process algebra
   - Express guards as state machines
   - Prove bisimulation with original API
2. **Tool Integration**:
   - Connect jGuard to LTSmin
   - Automated verification of contracts
   - Counterexample generation
3. **Scalability**:
   - Use his parallel algorithms
   - GPU acceleration techniques
   - Symbolic methods

Connection to His Work:

- Applies his verification expertise
- Uses SVL infrastructure
- Extends model checking to new domain

Project 3: Quantum Algorithms for API Synthesis

Goal: Automatically synthesize optimal jGuard specifications

Technical Approach:

1. **Synthesis as Optimization**:
   - Define API safety as optimization problem
   - Use quantum annealing
   - Find minimal guard sets
2. **Divide & Quantum**:
   - Break large APIs into components
   - Quantum synthesis per component
   - Classical composition
3. **Practical Implementation**:
   - Work with consortium partners
   - Test on real quantum hardware

- Compare with classical approaches

Benefits:

- Novel application of quantum
- Fits Divide & Quantum project
- Industry relevance through consortium

How to Present Your Ideas

Opening:

"Your work on bridging quantum and classical computing resonates with my API verification research. Both face the challenge of making theoretical advances practical..."

Key Points to Emphasize:

1. **Verification Connection**: jGuard needs scalable verification
2. **Quantum Opportunity**: API problems map to quantum advantages
3. **Practical Focus**: Real-world impact, not just theory
4. **Tool Integration**: Build on existing infrastructure

Technical Terms to Use:

- **"State space explosion"**: Why verification is hard
- **"Bisimulation"**: Proving equivalence
- **"Weighted model counting"**: His technique for quantum
- **"Hybrid algorithms"**: Best of both worlds

Questions to Ask Him

1. "How can quantum algorithms help with state space explosion in API verification?"
2. "What's the potential for applying LIMDD to software verification?"
3. "How do you see formal methods evolving with quantum computing?"
4. "What industry partners might be interested in verified APIs?"

Potential Joint Activities

Papers:

1. **"Quantum Model Checking for API Contracts"**
    - Venue: CAV or TACAS
    - First quantum approach to API verification

2. **"LIMDD for Software State Spaces"**
   - Venue: SPIN or FM
   - Extend his decision diagrams to software
3. **"Hybrid Classical-Quantum API Synthesis"**
   - Venue: POPL or PLDI
   - Novel synthesis approach

Grants:

- **Quantum Software** (NWO/EU calls)
- **Formal Methods for AI** (Horizon Europe)
- **Industry collaboration** through his consortiums

Tools:

- jGuard-LTSmin integration
- Quantum API verifier
- LIMDD for software

Understanding His Values

Research Philosophy:

- **Practical Impact**: Theory must solve real problems
- **Tool Building**: Create usable software
- **Interdisciplinary**: Connect different fields
- **Open Science**: Share tools and data

What Excites Him:

- Pushing boundaries of what's verifiable
- Making quantum computing useful
- Parallel and distributed algorithms
- Building research communities

Strategic Advantages

For You:

1. **Verification Expertise**: Prove jGuard correct
2. **Quantum Future**: Position for next computing era
3. **Tool Infrastructure**: Access to LTSmin, LIMDD

4. **Industry Connections**: Through consortiums

For Him:

1. **New Application**: Software verification via quantum
2. **Practical Problems**: APIs are everywhere
3. **Theory Challenge**: Interesting verification problems
4. **Expand Impact**: Beyond traditional domains

His Network & Resources

Key Collaborations:

- **QuTech** (TU Delft): Quantum hardware
- **CWI Amsterdam**: Algorithms research
- **Industry**: EDF, Volkswagen, Google, Atos
- **EU Consortiums**: Large-scale projects

Infrastructure:

- SVL computing cluster
- Access to quantum simulators
- Industry case