Software Powering Network Experimentation

How Software Networks can help in improving reproducibility in ICT

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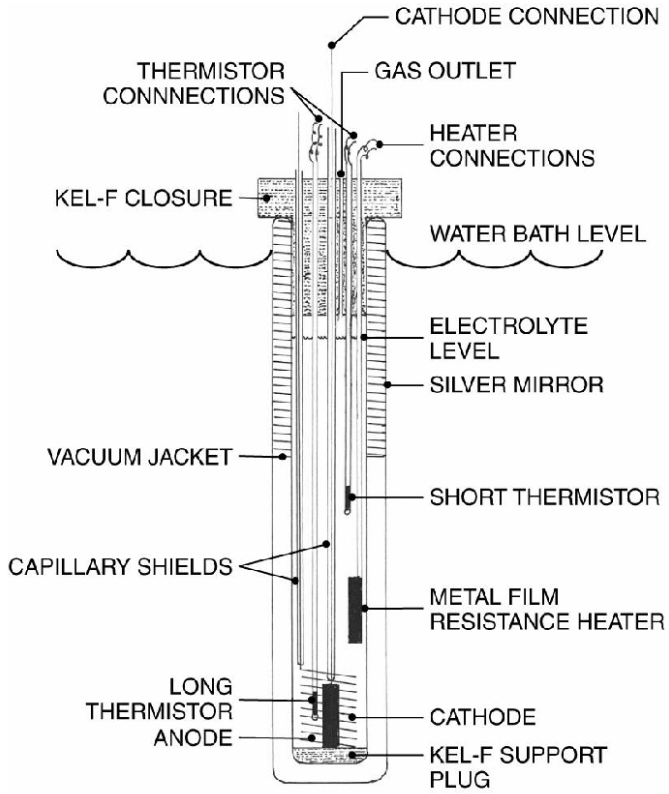
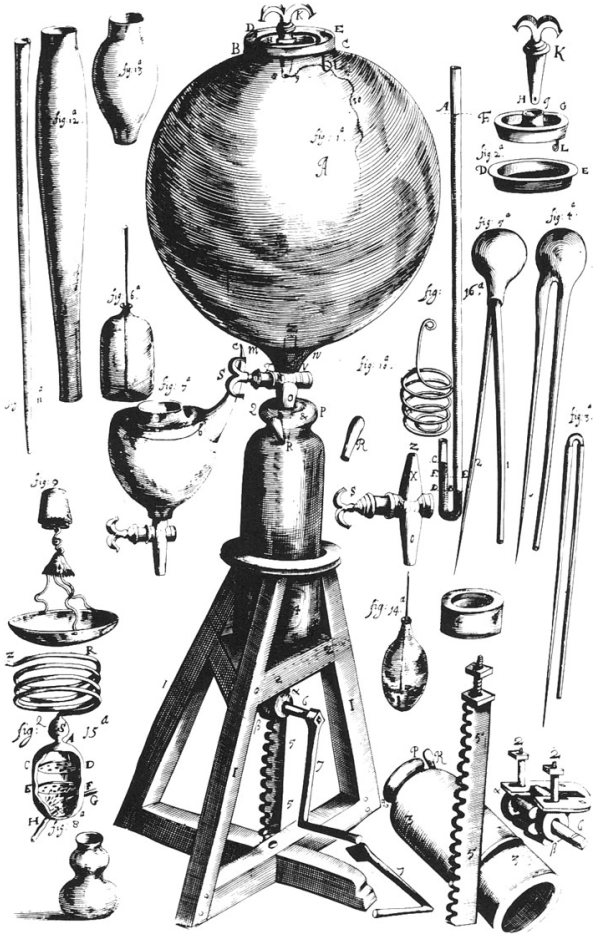
Making Serious Science (and Engineering)

- Independent verification and *reproducibility* are essential to the scientific method
  - *"Non-reproducible single occurrences are of no significance to science" (K. Popper)*
- Complicated in many cases because different reasons
  - Ethical
  - Nature of the research field
- Recent computing and network results
  - Complexity
  - Disparate conditions



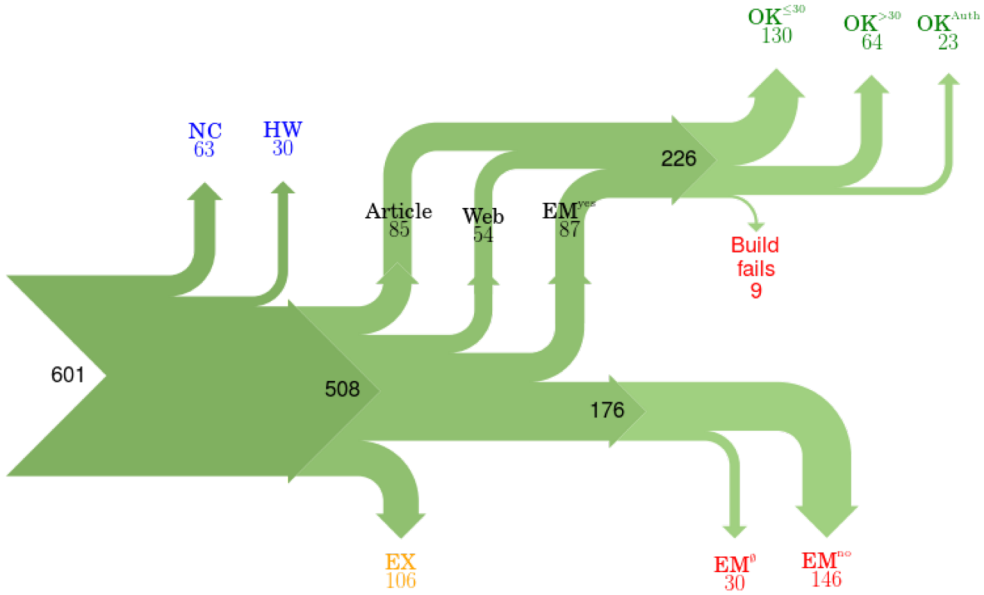
Essential Goals

- Corroboration
  - Avoid (un)intentional idiosyncratic results
  - Repeatable results
- Transparency
  - Avoid (un)intentional biases
  - Environment and measurements
  - Repeatable methods
- Robustness
  - Avoid (un)intentional best-of-breed results
  - Repeatable causes



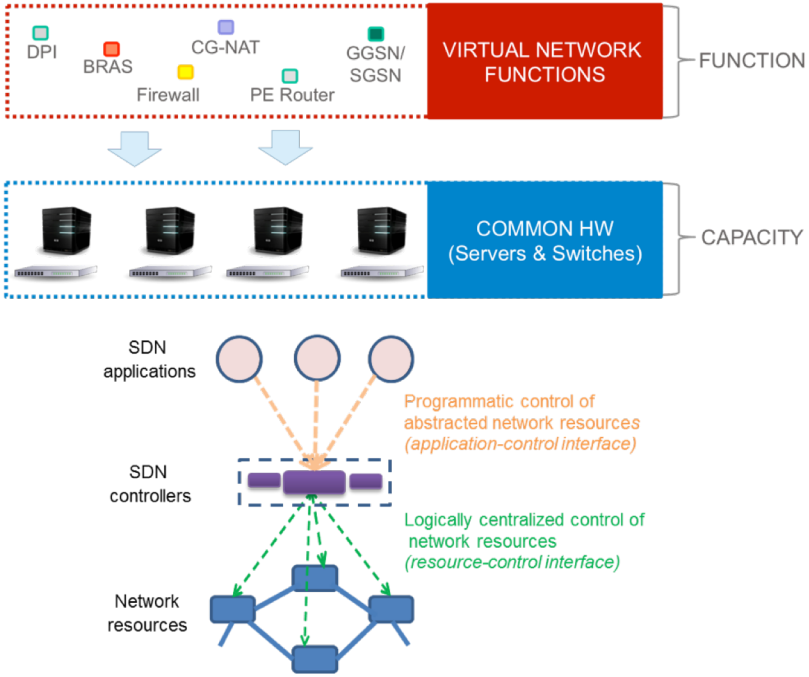
The ICT Front

- Reproducible result reports are not common
  - Complex environments
  - Incomplete descriptions
  - Too-focused measurements
  - Limited variations
- This is not just an academic issue
  - Technology evaluation
  - Strategic planning
  - Multi-domain environments
  - While shortening the cycles



http://repeatability.cs.arizona.edu/

How Software Networks Come to Help



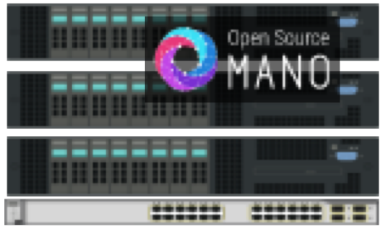
- More regular infrastructure
  - Easier to match environmental parameters
  - More homogeneous measurement points
- Model-based approaches
  - Consistent descriptions
  - Scalable verification
  - For environments and experiments
- And, well, software based
  - Virtualization as a transportation guarantee
  - Open source

The OSM Example

LOCAL DEVELOPMENT &TESTING

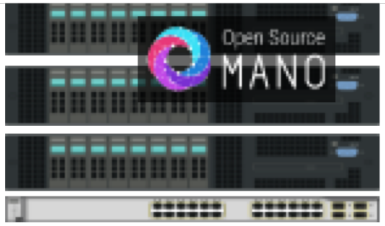
- Open development environment
- Functional tests
- Low cost
- Integration from the beginning

TEST POOL FOR DEVELOPERS



- Real servers and switches
- Performance tests (EPA can be enforced)
- Cost-effective shared infrastructure
- Move the value to VNF services

SERVICE PROVIDER



- Production/pre-production environment
- Real network scenarios
- Final service configuration
- Fast deployment
- Low final integration cost

Applying network-aware CI/CD principles

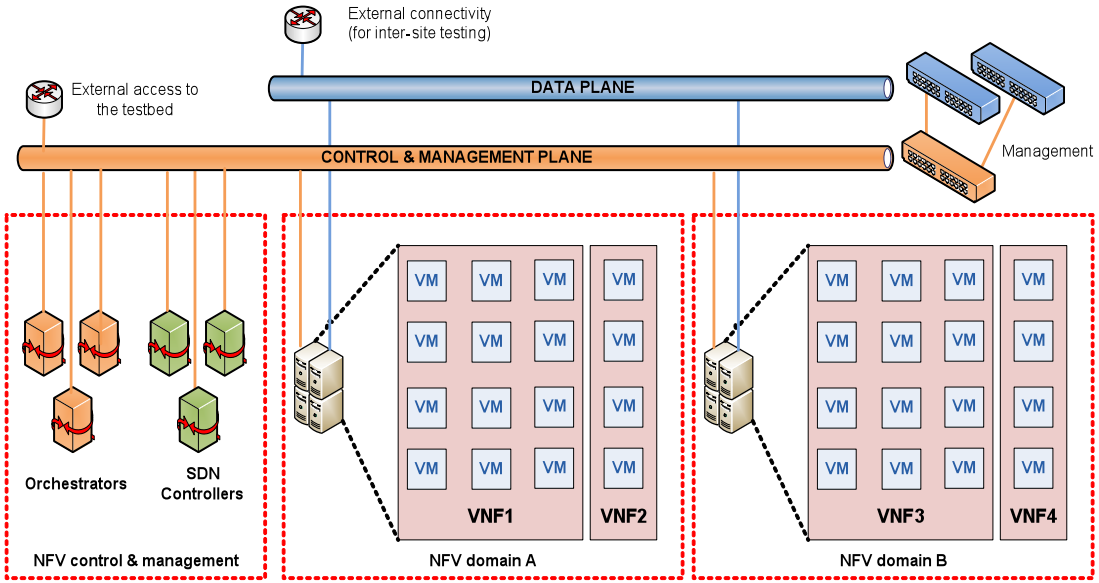
- Development and testing
- Experiment description and sharing

5TONIC

- An open research and innovation ecosystem for 5G products and services
  - Created in 2015, based on the direct collaboration between Telefónica and IMDEA Networks
  - With a current roster of 10 *members* and 5 *collaborators*
- Intended to become a central hub for knowledge sharing and industry collaboration in the area of 5G technologies
  - Across the global Telefónica footprint
  - With direct participation of vertical representatives

The 5TONIC Software Network

- All 5TONIC infrastructure follows the Software Network principles
  - The only exception is dedicated physical devices for access technologies (radio, fiber…)

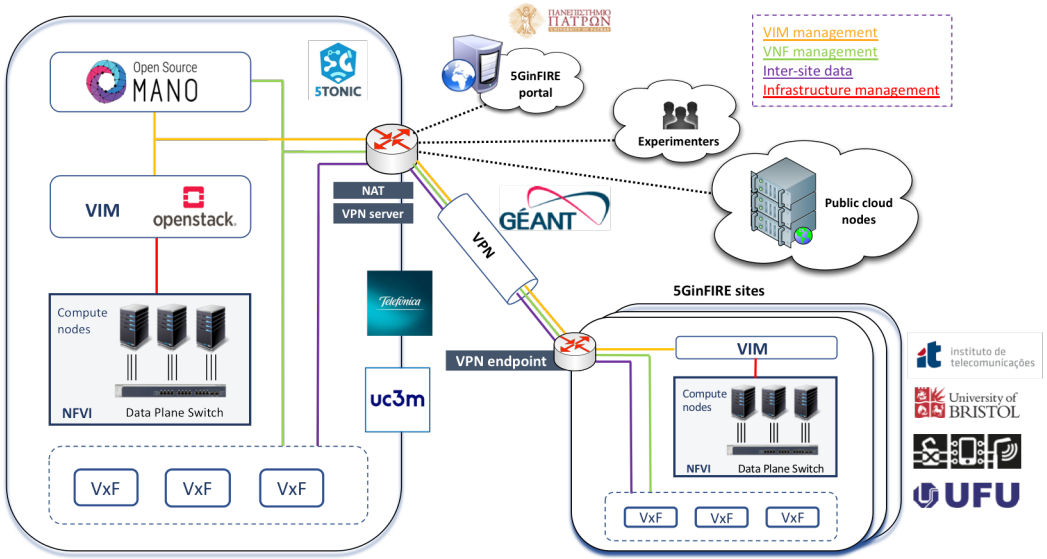


- Mini and single-board computers
  - VNF hosting, virtual switches and other network elements
- SDN-enabled switches
  - High performance fabric

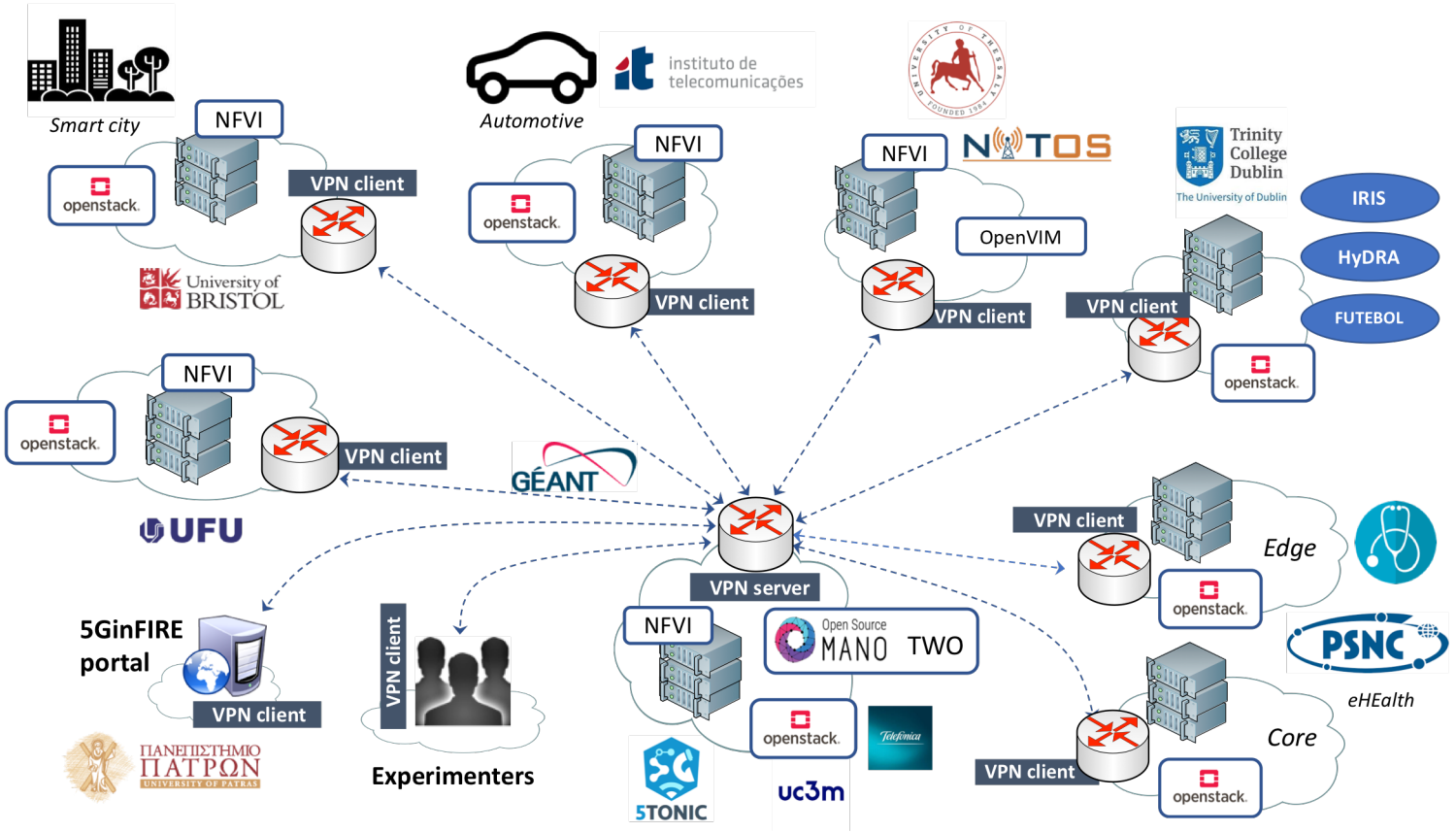
- High-performance servers
  - Management, control, orchestration
  - Data analytics, high-end computational tasks
  - Experimental data storage and management

Multi-Site Model-Based Experimentation

- 5GINFIRE provides a multi-site testbed
  - Expanding through FIRE Open Calls
  - Experiment-driven
- Centralized service and function orchestration
  - Applying OSM
  - Completely model-based
- Multi-domain orchestration considered
  - Exploring different APIs: NFV, MEF…

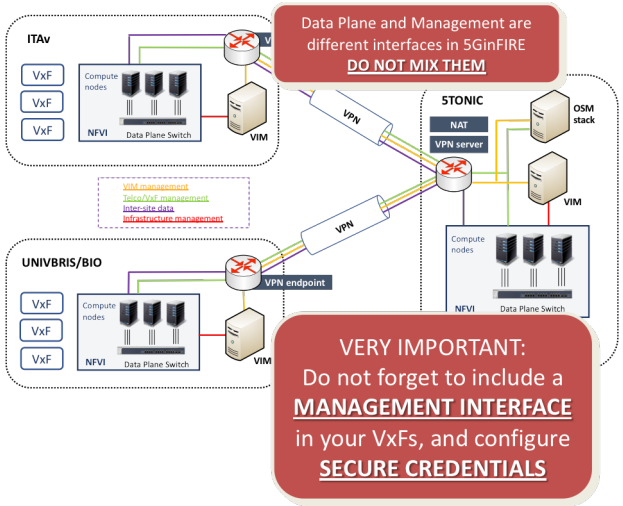


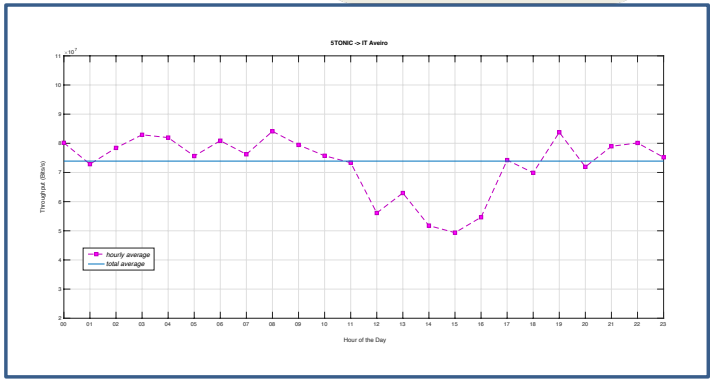
The Current 5GINFIRE



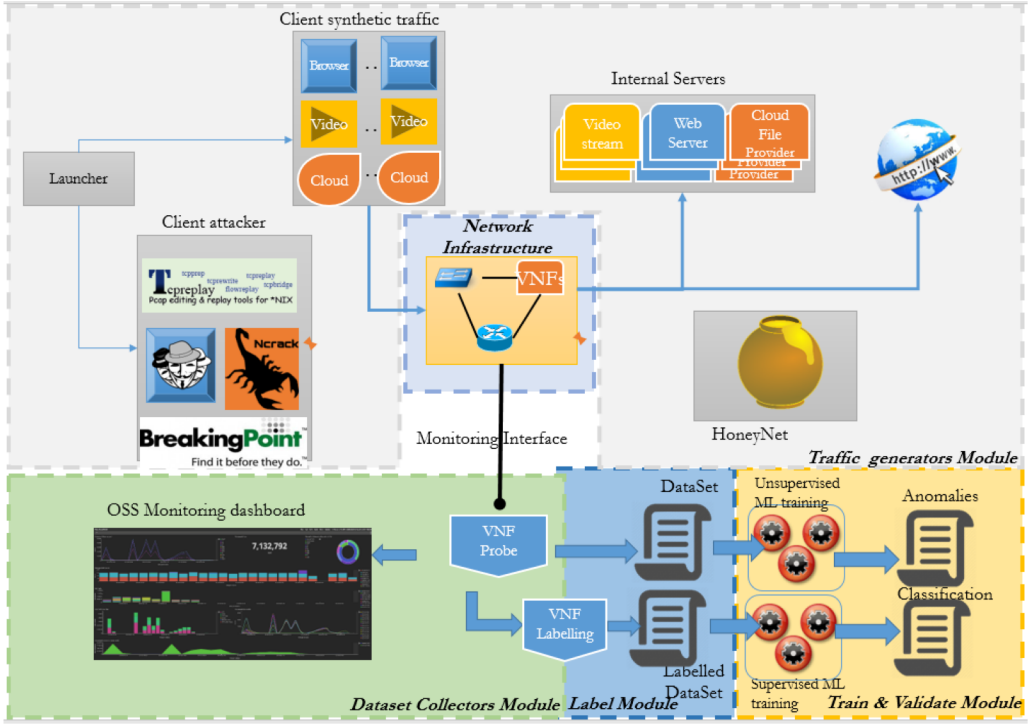
A Few Challenges and Lessons Learned

- Security and trust issues in multi-domain scenarios
  - Consistent approach at all layers
- Acceptance and troubleshooting
  - Incorporating new sites and identifying causes
- Extend the model-based approach
  - Constructs for monitoring, measurement, telemetry…
  - Continuous integration at the orchestration and functional levels
  - Service continuity and model-based testing
- Connectivity matters
  - SDN in the WAN (not limited to a matter of trust)
  - Experimenter access to deployed functions
  - Function / infrastructure interactions: the SDN on NFV issues





Data Focus: The Mouseworld

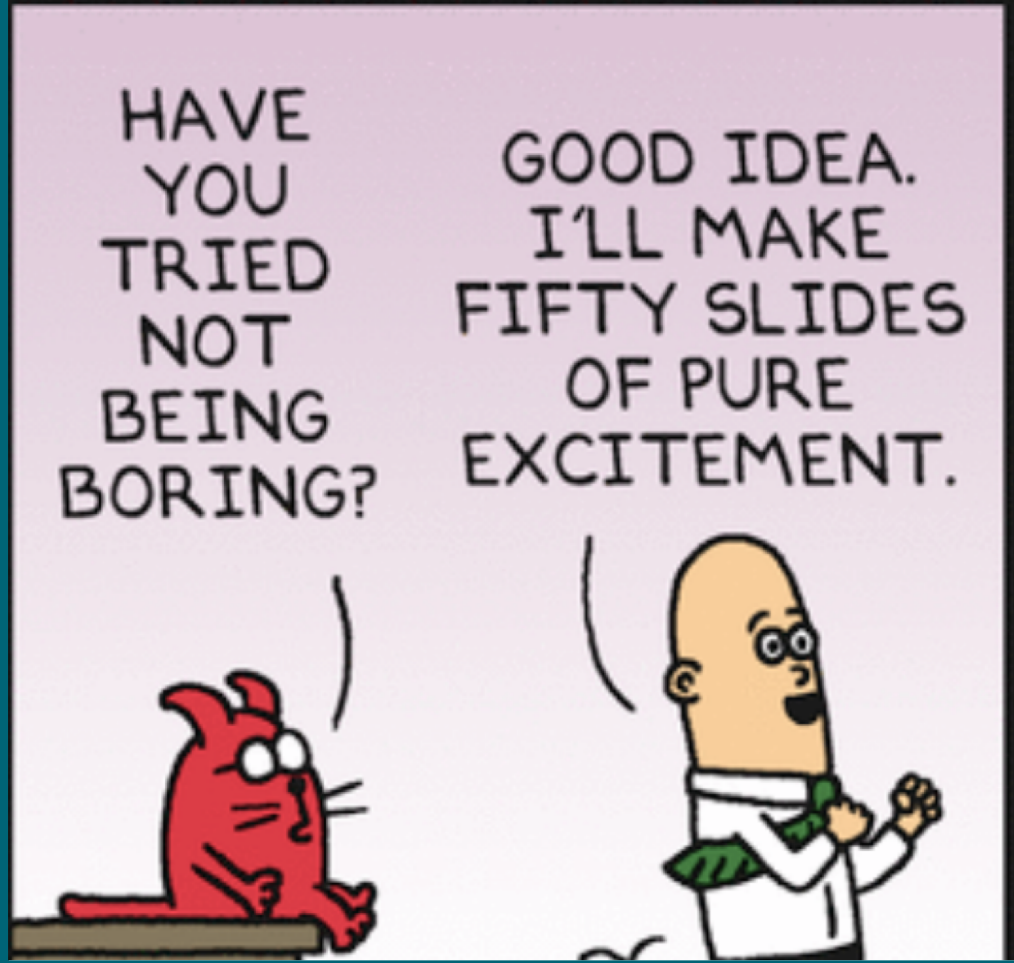


- Generate sound, bespoke datasets
  - Validate close-loop control, especially AI-based ones
  - Train and evaluate ML in different network management scenarios
- Rely on Software Network principles
  - Traffic mix generation
  - Dataset collection
  - Dataset labelling
  - Training and validation loops

Powering Experimentation

- The Software Network opens several paths to improve network experimentation
  - And make it *real science* again
  - Avoid networking cold fusion
- Not only academic goals
  - Real engineering requires real science
- First steps taken
  - Towards model-driven experimentation

Telefónica


HAVE YOU TRIED NOT BEING BORING?
GOOD IDEA. I'LL MAKE FIFTY SLIDES OF PURE EXCITEMENT.