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Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

Massive Multi-Agent Simulation
-
Master Seminar

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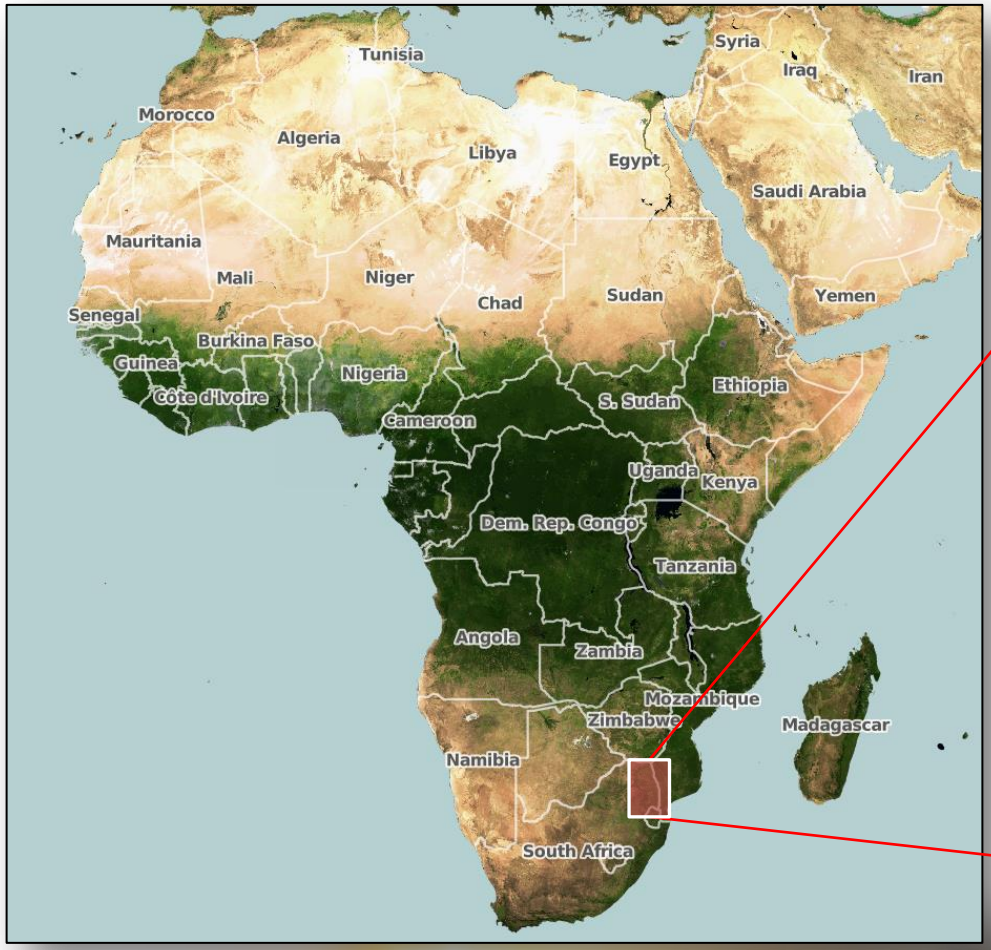
Agenda

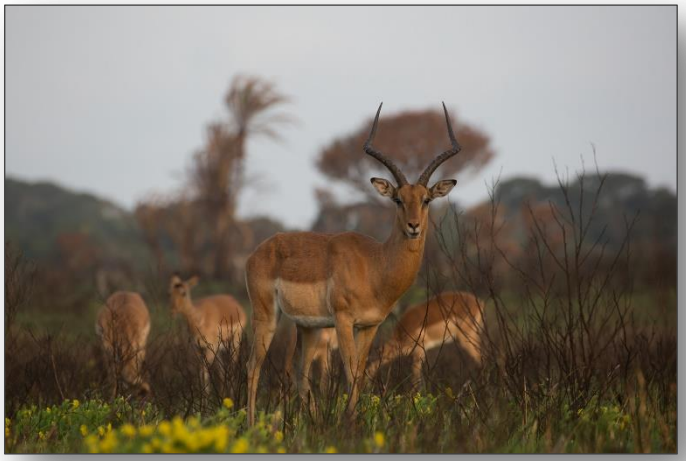
1. A new Showcase
2. Kruger National Park Model
3. Mapping KNP to MARS
4. My Focus
5. Distribution & Scaling Concepts
6. The story so far
7. Hypotheses
8. Chances & Risks

A new Showcase: The Kruger National Park



The Kruger National Park model

- 20.000 km^2 of landscape
- 16.000 Elephants
- 200.000 Impalas
- 300 Cheetahs
- 90 meters resolution



The Kruger National Park model

- Ecological Research example:
  - Effect of water point closure on elephant density and landtype

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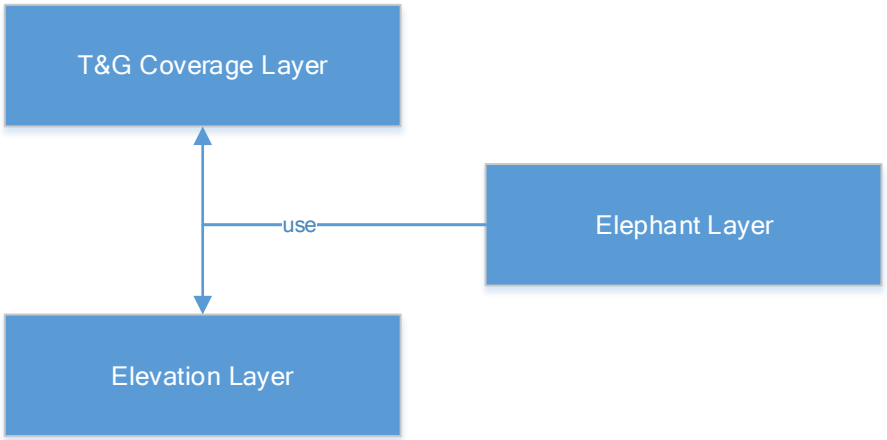
Why massive?

- Mengistu, D. (2011) :
  - Many MAS applications stay behind their possibilities because of scale problems
  - 50 % of examined MAS papers are not verifiable
  - The two MAS papers with most agents don't even state how the results were achieved
- Hilbers et al. (2014) state necessity to simulate KNP on "ecosystem level"
- Cioffi-Revilla et al. (2002):
  - "Group or System size matters for systems and processes involving collective action (…)."
  - "Results need to be validated with respect to system size to ensure simulation results are not purely local for a given system size."

Mapping the KNP model to MARS

Basic MARS modelling concept

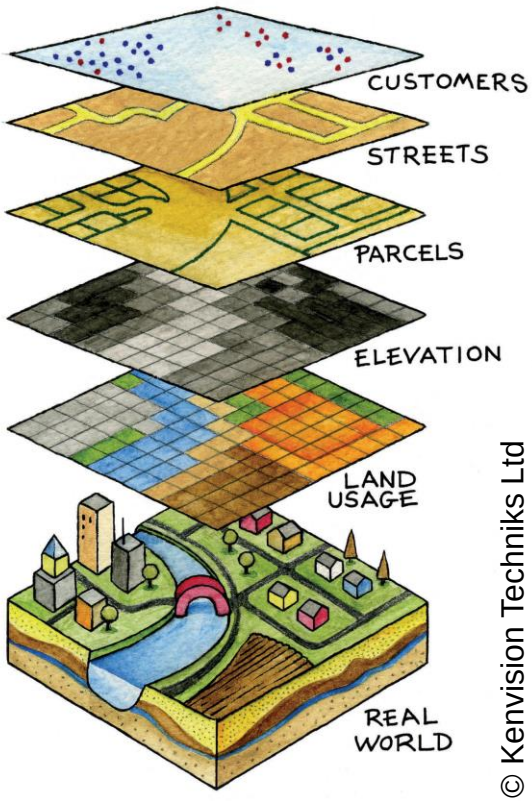
- Layer Approach:
  - Borrowed from GIS data types
  - One Layer per model aspect
  - Composition of layers builds the environment
  - Agents live on layers
  - Layers are plugins



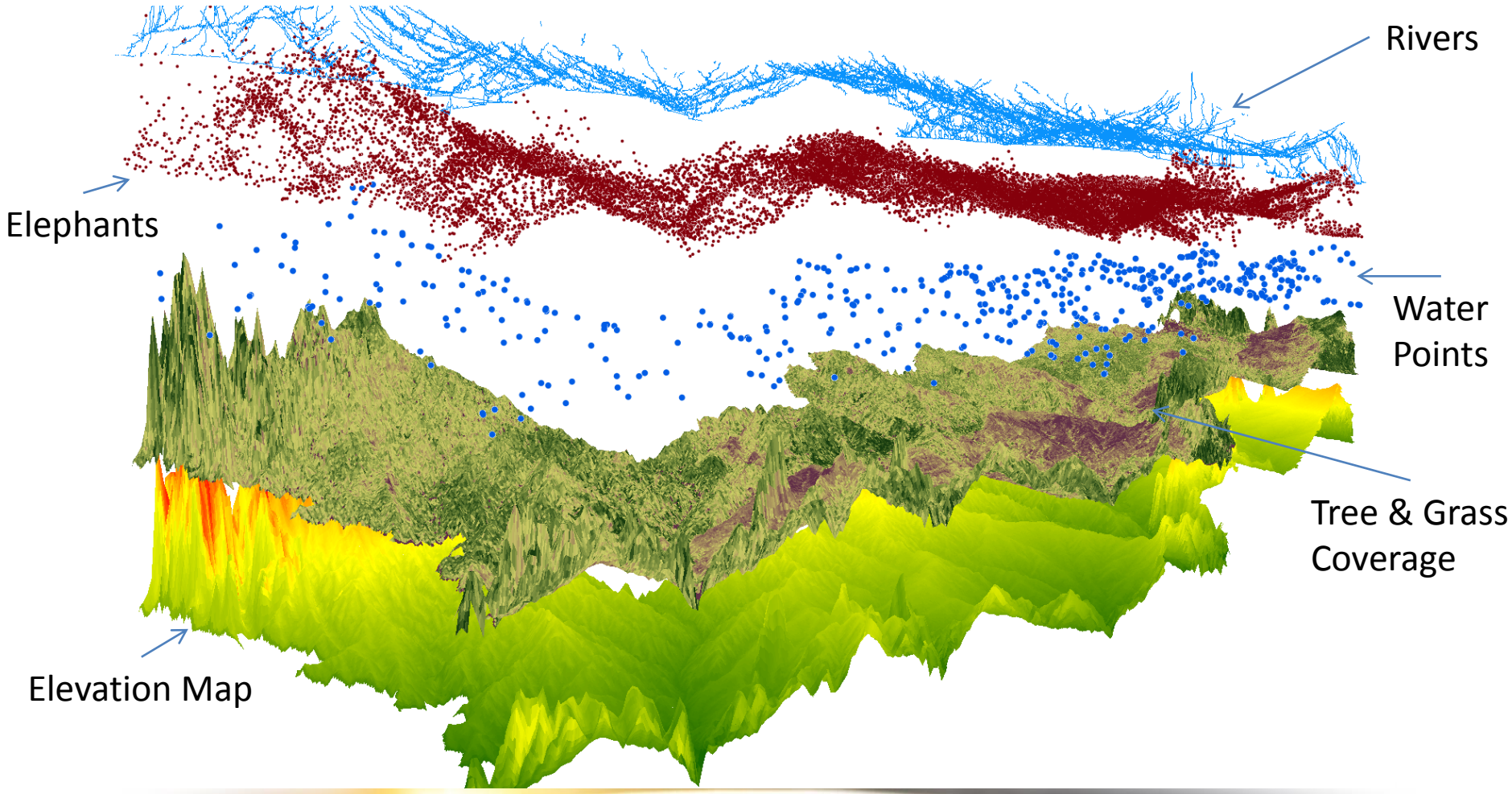
- Enables:
  - Modularization
  - Application of Software Engineering Practices
  - Reusability of models thanks to defined interfaces

Mapping the KNP model to MARS

- Environment as composition of 6 different datasets:
  - Point coverage for Elephant and Impala density
  - Rivers
  - Waterpoints
  - Grass and tree coverage (T&G)
  - Landtype
  - Elevation Map



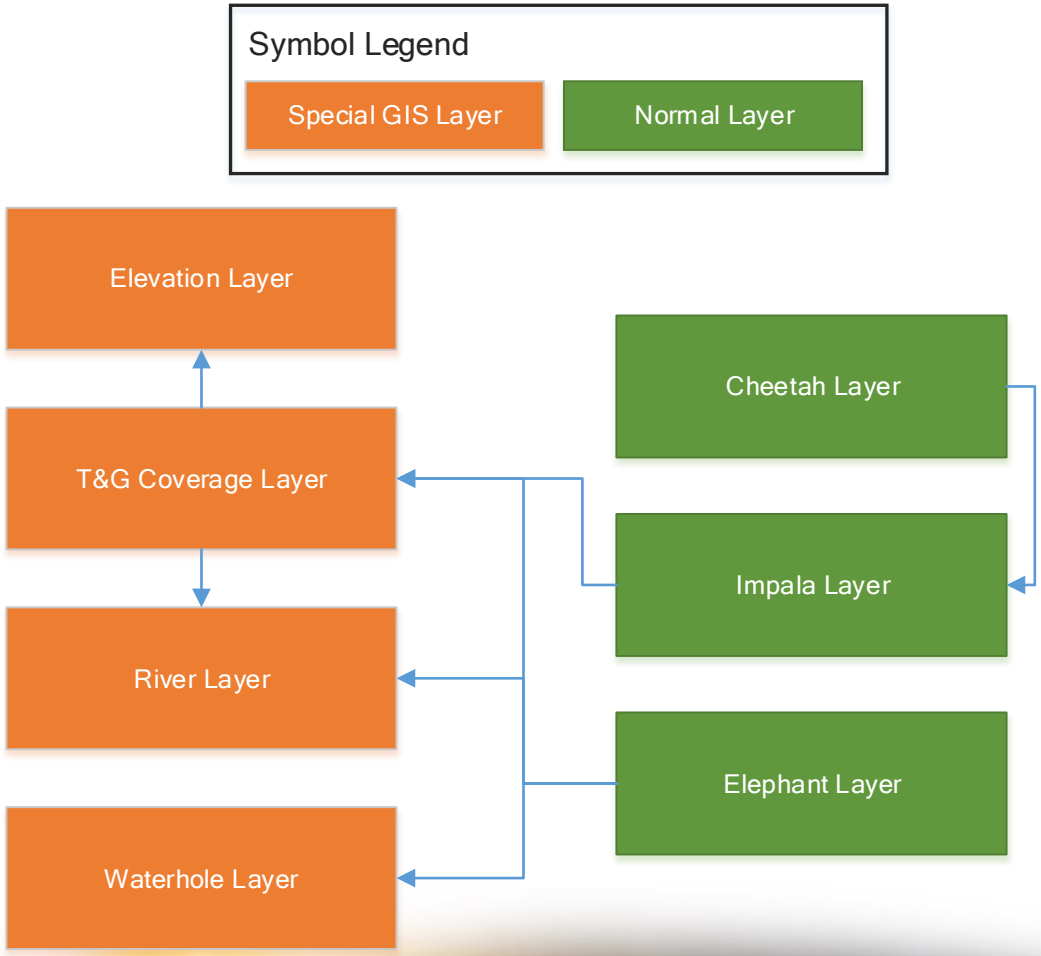
Mapping the KNP model to MARS



Mapping the KNP model to MARS

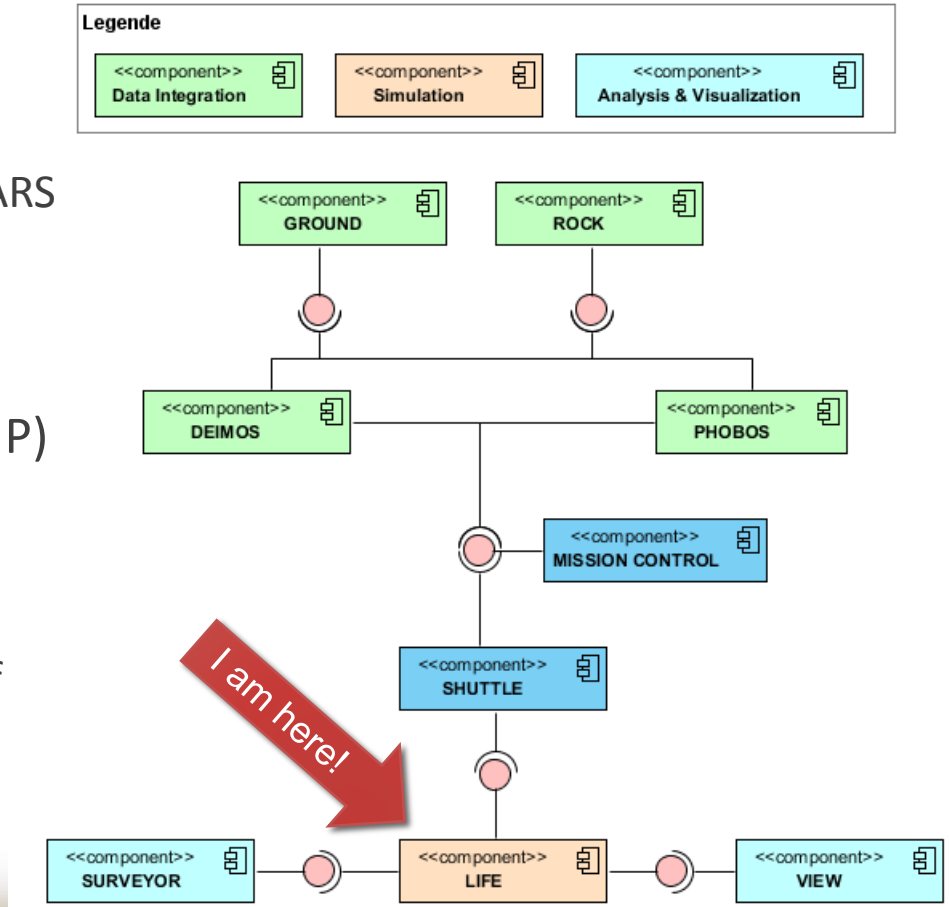
- GIS data to specialized MARS GIS Layers
  - Allows spatial queries!
  - Useful for land type, rivers and water points
- Use Elevation Map to initialize Environment Service Component (ESC)
  - Place objects in 3D space
  - Allow efficient spatial movement and exploration
- Elephant and Impala models
  - Agents
  - Each live on their own layer
  - Initialize elephant / impala layer with density map

Mapping the KNP model to MARS



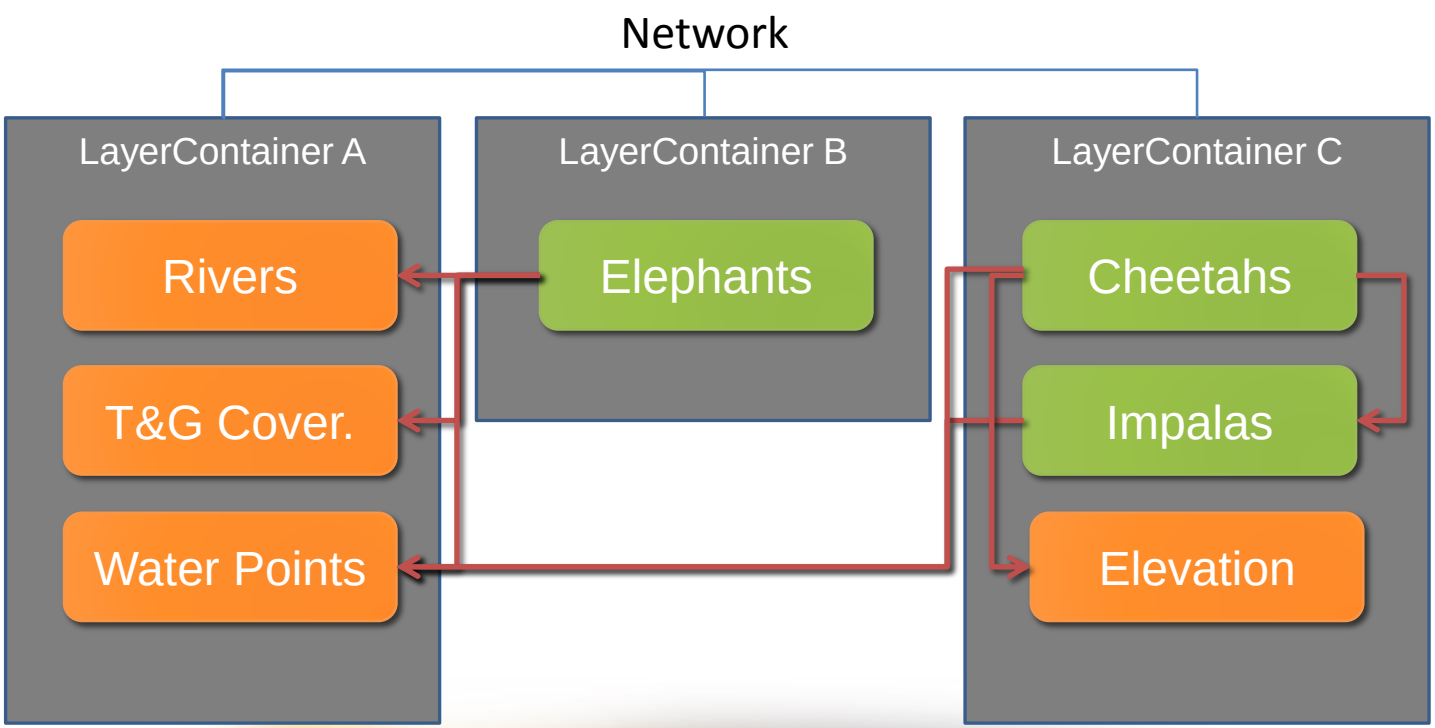
My Focus

- MARS LIFE
  - Scalability
  - Architecture allows for good integration and usability with MARS ecosystem
- Create a Kruger National Park (KNP) model in MARS LIFE
  - Not a validated model from ecologists perspective
  - Proof of concept for scalability of MARS LIFE



Distribution & Scaling Concepts

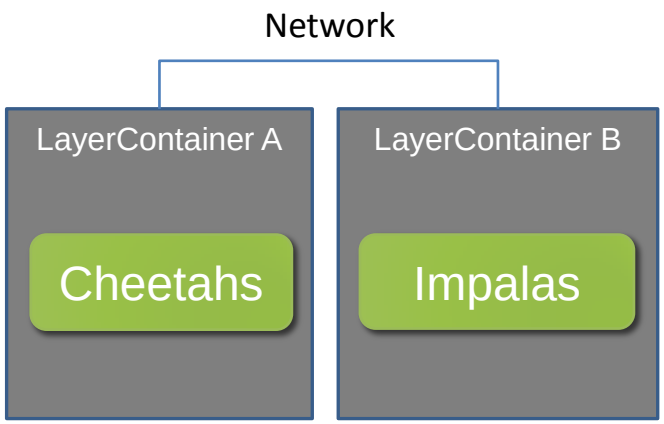
- Model translated to MARS paradigm
- Distribution of model via LayerContainers in MARS LIFE, e.g.:

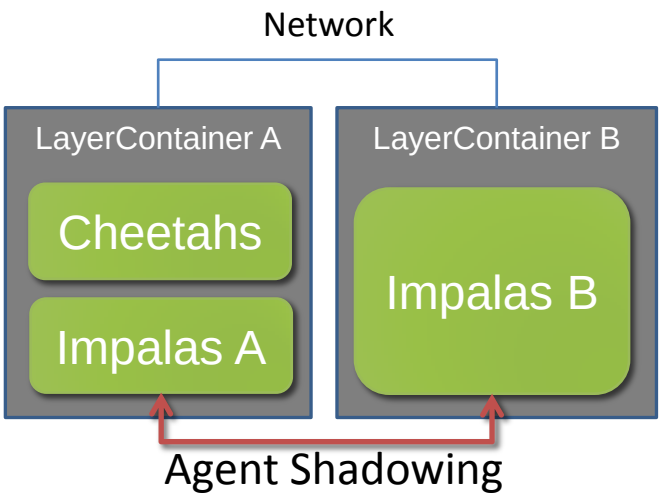


Distribution & Scaling Concepts

Scaling the Agents

- 2 distribution options:

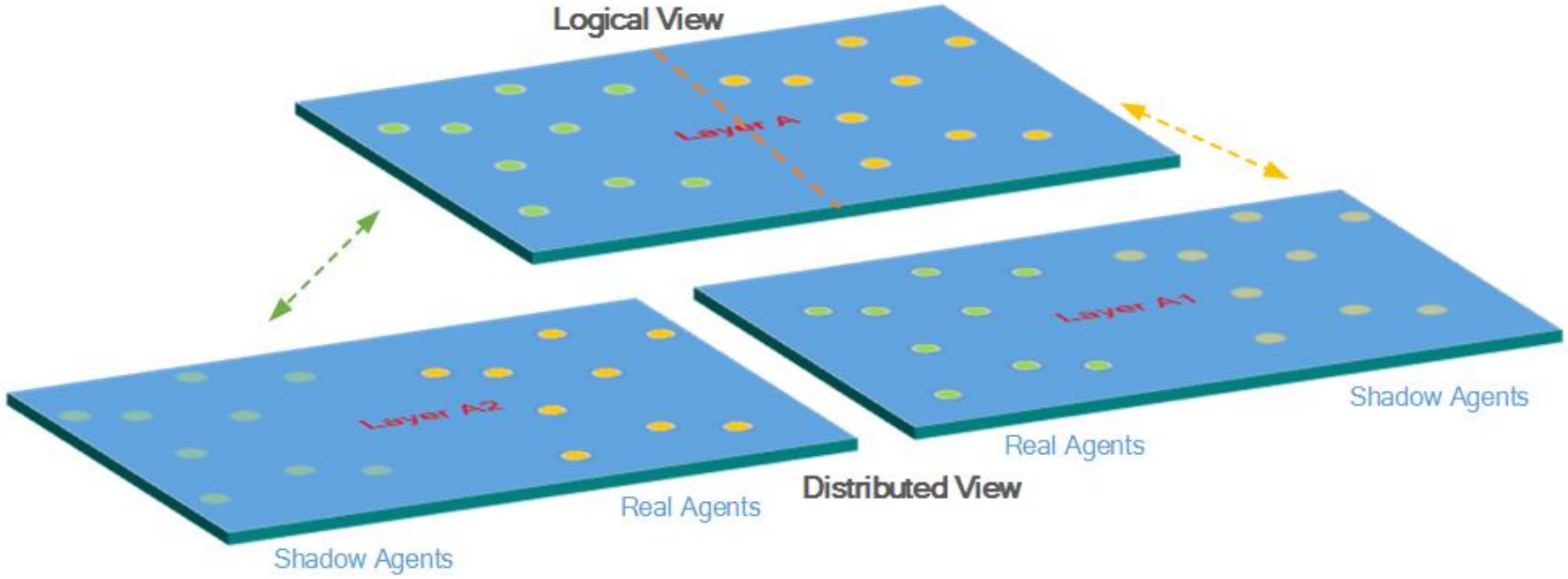




Distribution & Scaling Concepts

Scaling the Agents

- Agent Shadowing:
  - Remote-calls take a long time
  - Every Layer instance holds all agents
  - But: Just a small part of agents as real implementation, all other entities as stubs
  - Transparent to the developer!
  - Caching & PUSH mechanism for agent attributes



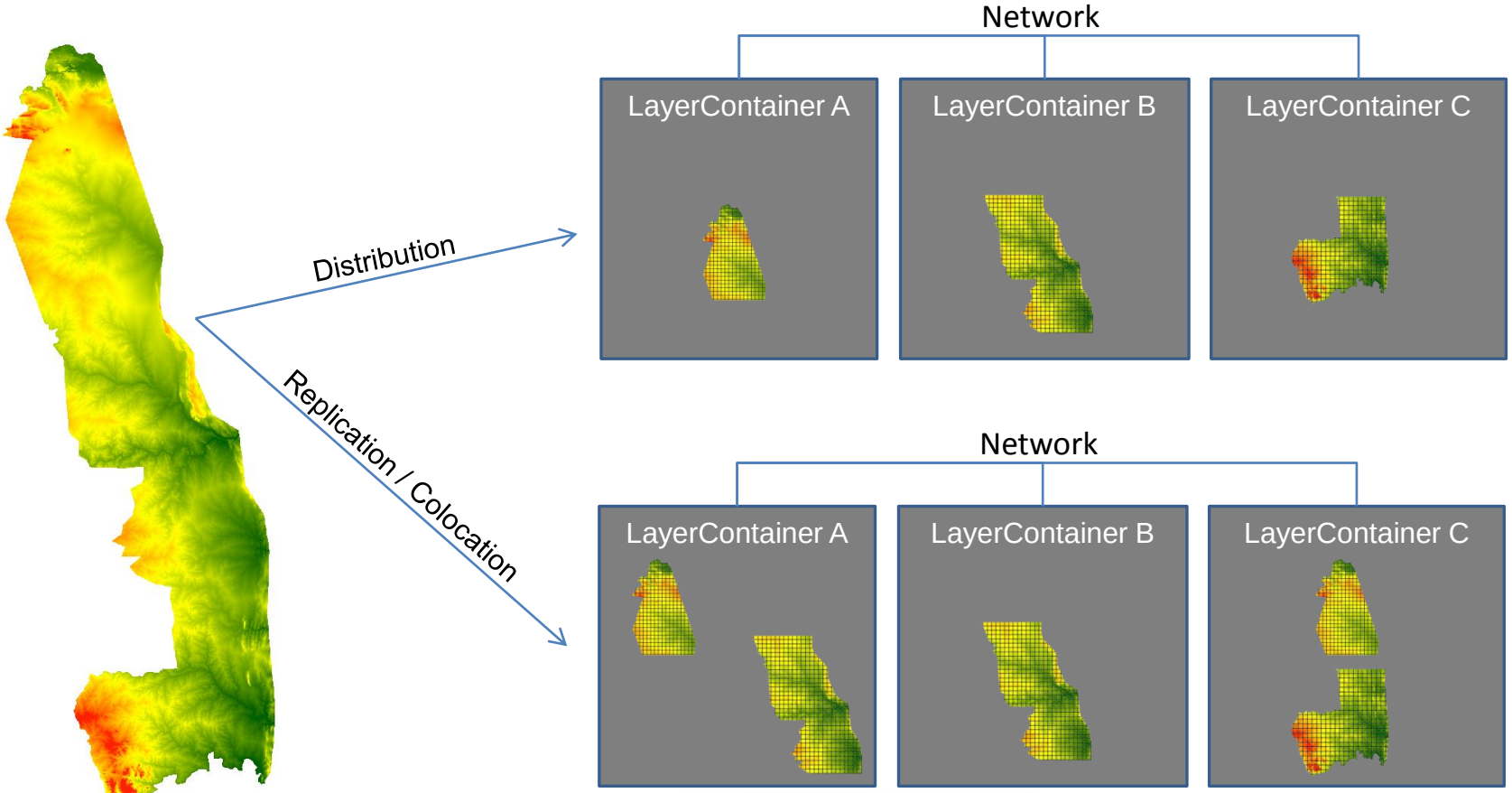
Distribution & Scaling Concepts

Scaling the environment

- Environment in ecological modelling often fed from GIS files
- GIS files may be loaded into special LIFE layers
- GIS files may be splitted
  - by attributes
  - by features
  - by custom filters, scripts etc.

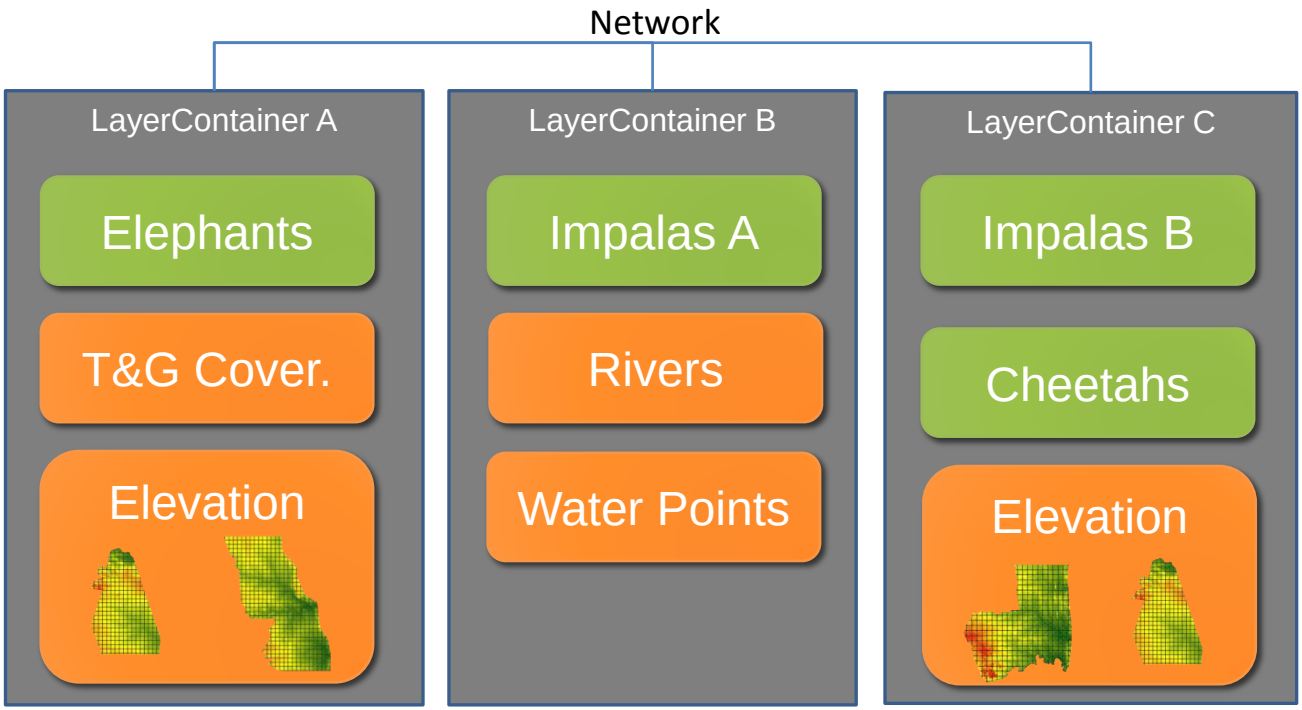
- So LIFE layers may be splitted and / or replicated by the same means
- Read only! → ESC

Scaling the environment



Distribution & Scaling Concepts

Complete view:



The story so far

- AW1 :
  - Overview of area of research

- AW2 :
  - Analysis of competing systems, concept and solutions
  - Finding the gap (Scalability and Usability)
  - Collecting requirements

The story so far

- PO1 : Setup of experimentation environment
  - Virtual MARS simulation cluster
    - Controllable via WebApp → "Simulation As A Service" !
  - MARS Model Developer Edition to focus on model development
  - MARS LIFE Dev Services
    - Bare-API
    - Service augmented simulations

- PO2 (In progress) :
  - Implement missing MARS LIFE components
  - Implement KNP model
  - Conduct experiments & hunt bugs

Hypotheses

1. MARS is capable to scale by a constant factor when hardware is added
2. MARS is capable of executing any given model in near real-time given enough hardware
3. It is possible to translate every model to the MARS paradigm of layers and agents
4. The MARS LIFE architecture allows to attach tools usable by domain experts whilst maintaining performance

Chances & Risks

- Risks
  - Memory consumption of Agent Shadowing might become show stopper on very(!) large models if no sufficient garbage collection algorithm can be found

- Chances
  - Use massive scale models to capture “Black-Swan” events
  - Allow MAS to be a tool for ecosystem scale research
  - Enable researchers with limited hardware to work with MARS
  - Share models, layers and agents among researchers using MARS

Thank you for your attention!

Sources

(Hilbers et. al., 2014): Elephant-mediated cascading effects of water point closure in Kruger National Park , South Africa, 1–32.

Mengistu, D. (2011): *Improving the performance of distributed multi-agent based simulation*. Blekinge Institute of Technology. Retrieved from http://www.diva-portal.org/smash/record.jsf?pid=diva2:679886

Cioffi-Revilla, C. (2002): Invariance and universality in social agent-based simulations. *Proceedings of the National Academy of Sciences of the United States of America*, *99 Suppl 3*, 7314–6.