Simulation Verification and Validation as a Service

"Advancing simulation theory, methodology, and practice through solving one challenge at a time."

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My research focus is advancing ..

Domain knowledge using computational methods	Modeling and Simulation field
Urban Science • Home location prediction • Tourist movements and sentiment • Mobility analysis from sparse footprints Cybersecurity • Malware projections • Malicious behavior modeling • Simulation for cybersecurity	Data-driven agents Web-based simulation (http://cloudes.me) Understanding the modeler Verification and Validation (V&V) • Spatial plots to convey simulation dynamics • Statistical debugging • Making a V&V service

Related publications are at http://hamdikavak.com/publications/

Summary

- Verification and Validation (V&V) is one of the most important steps in a modeling and simulation process.
  - There are over 170 V&V techniques proposed in the literature.
- Despite its importance and a vast number of available techniques, V&V is mostly applied in an **ad-hoc manner using informal techniques** or **not applied at all**.
- To improve V&V practice, this project aims to create a Verification and Validation (V&V) service accessible to a wide range of audience, including less technical people.

Our team

Hamdi Kavak (GMU)	Joon-Seok Kim (GMU)	Christopher Lynch (VMASC)	Peter Banks (GMU)
			
TBA	TBA	TBA	TBA
VACANT	VACANT	VACANT	VACANT

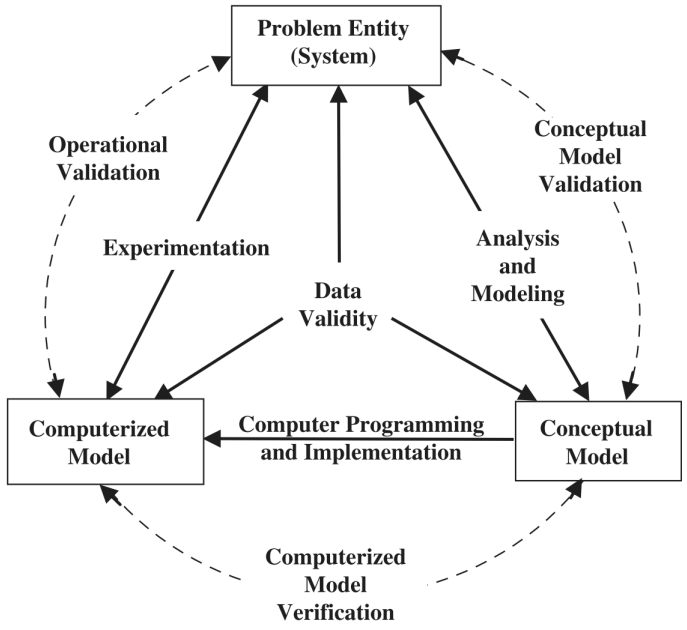
V&V terminology

- **Verification:** the process of determining that a simulation is built correctly [1-3].
  - Involves examining simulations' **structure**, **code**, and **behaviors** to identify implementation errors.

- **Validation:** the process of determining that a simulation adequately reflects the modeled system [4-6].
  - Involves examining simulations' **conceptual model**, **output data and its uncertainty**, and **sensitivity to parameter changes** …

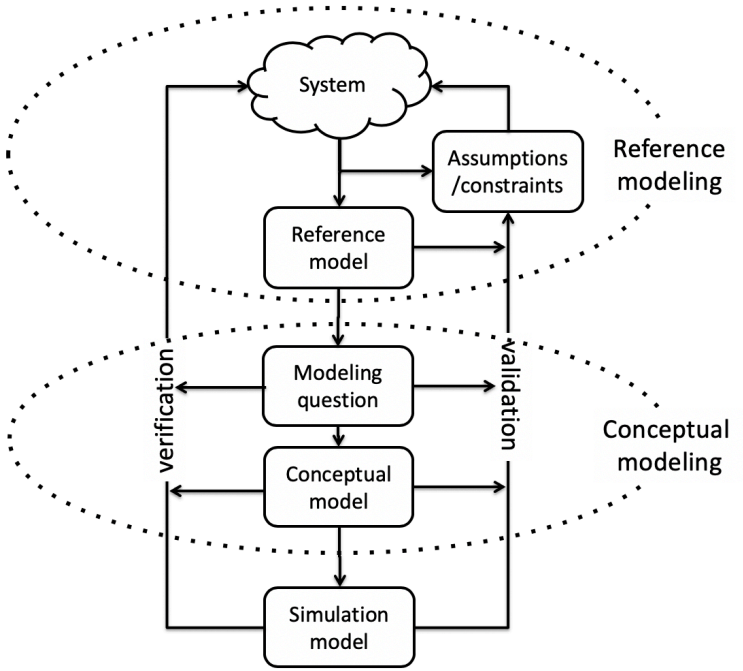
V&V in Modeling and Simulation processes

The model development process (simplified version)



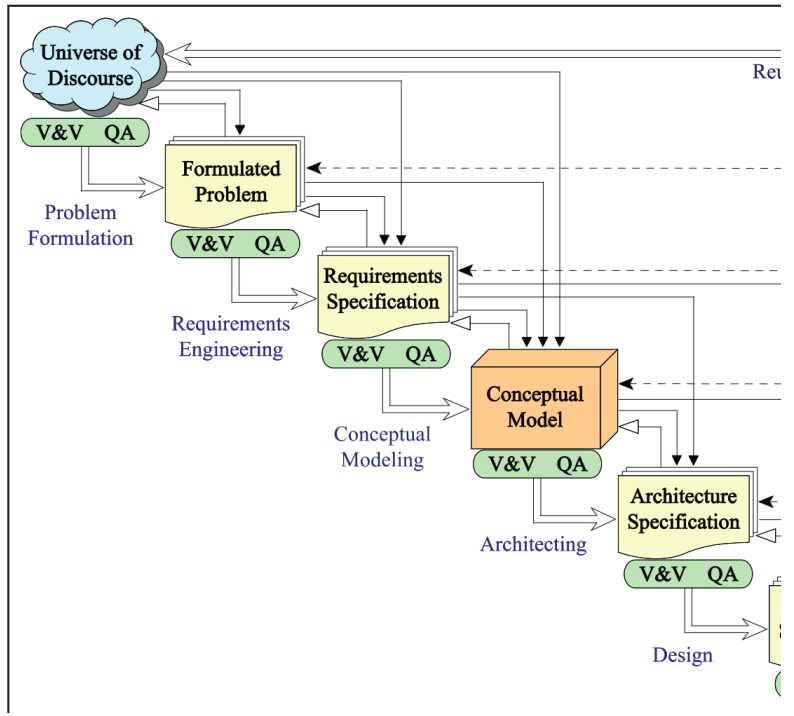
Sargent [5]

The M&S System Development Framework



Tolk et al. [7]

A life cycle for modeling and simulation

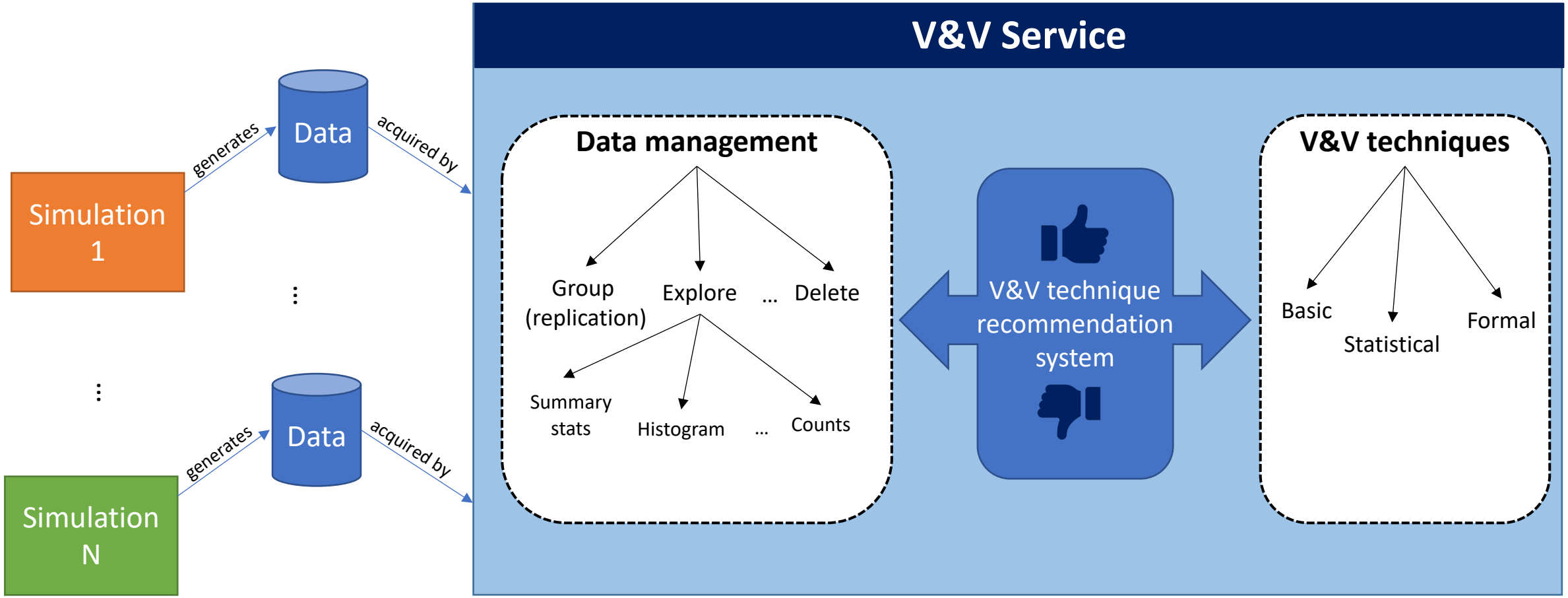


Balci [8]

Challenges in applying V&V

- **Resource requirement** (e.g., time) associated with V&V yields
  - Not conducting V&V at all
  - Using informal V&V techniques
- **Tradition of use** – using the same V&V techniques established by their peers, perhaps decades ago
- **High learning curve**, especially for formal techniques
- **Lack of commonly accepted solutions** yield
  - non-reusable efforts
  - time lost

Our proposal – a schematic view



V&V techniques to be included

Basic

- Visualization
  - Scatterplot, time series, spatial, histogram, heatmap, 3D, bar chart, box plot, network (graph)
- Animation
  - Traces, events, network evolution, change of histogram
- Event validity

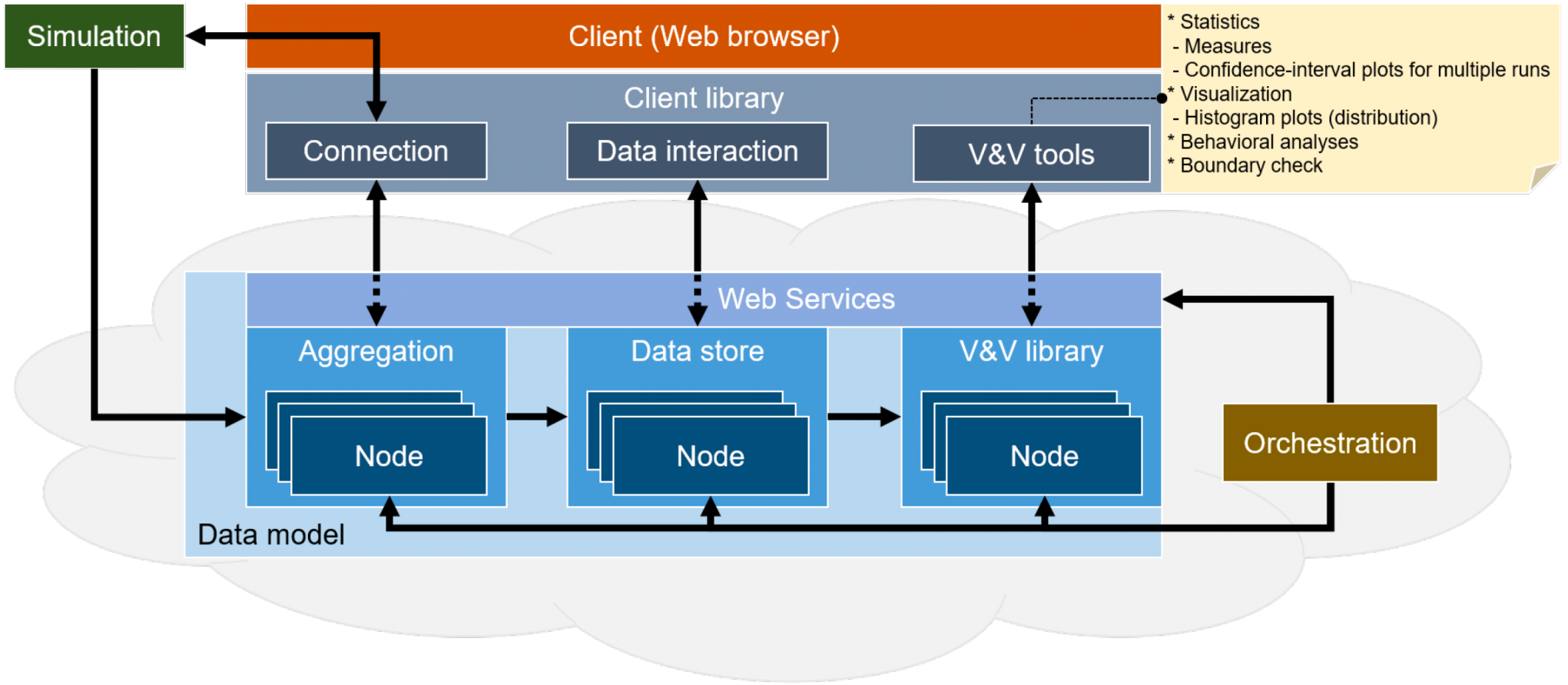
Statistical

- Simulation output validation
  - Historical data validation
  - Confidence intervals (uncertainty estimation)
  - Statistical tests
  - Distribution fitting
  - Network measures
- Sensitivity tests

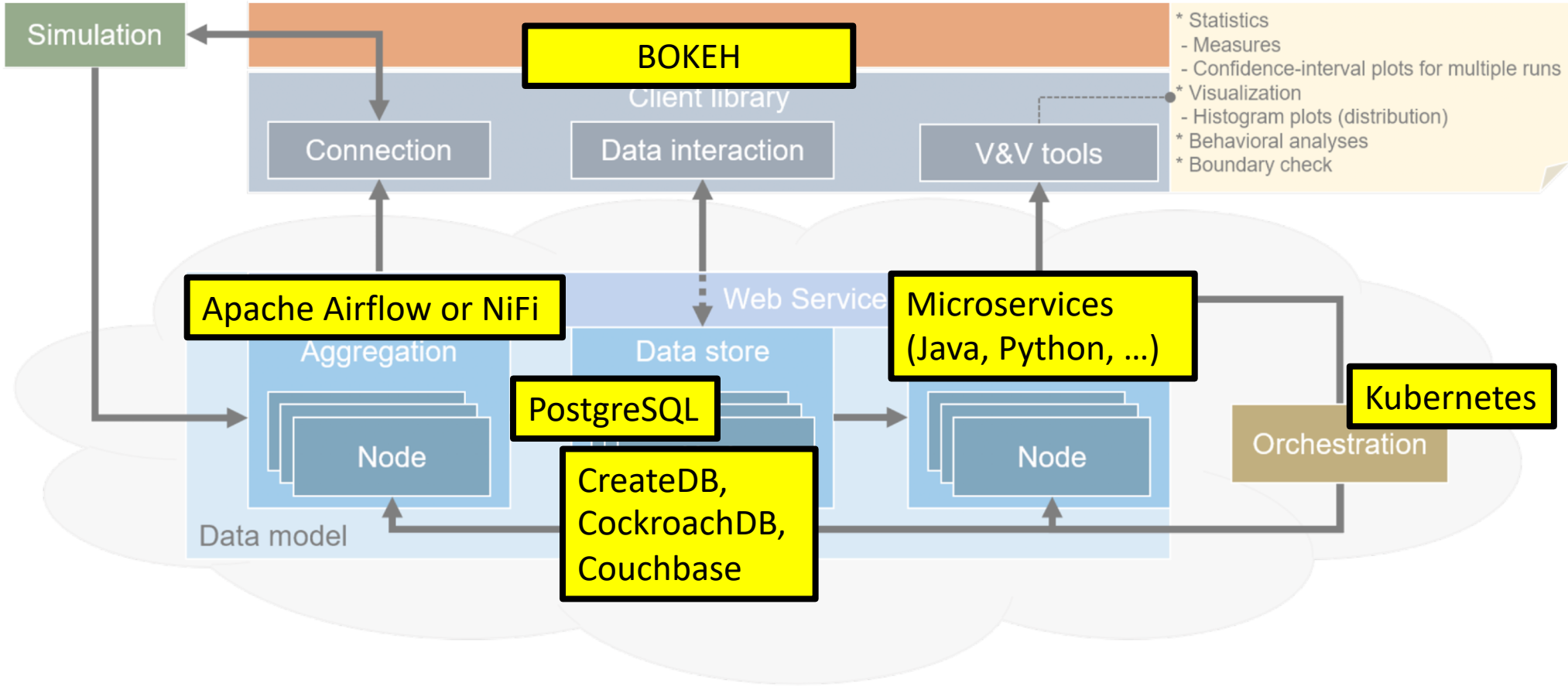
Formal

- Boundary checks via predicates
- V&V calculator via statistical debugging

System architecture



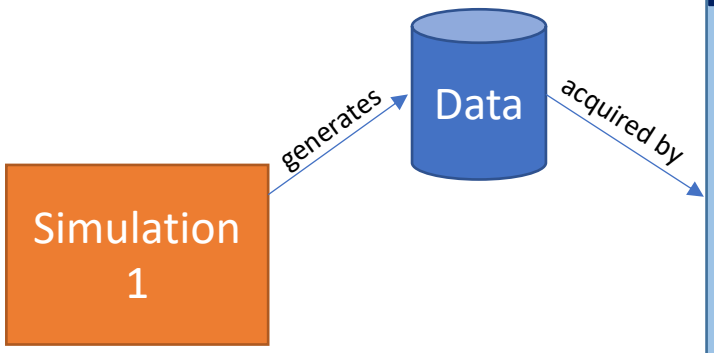
Software implementation (planned)



Planned features

- User experience
  - Seamless integration of data logistics for the user
  - Personal data via user management
  - Ability to recognize replications and certain data types (e.g., spatial)
  - Third party integration with web-based simulation tools
  - Custom reporting dashboard sharable via a web link
    - Can be used as a supplemental document for research papers
- System
  - Independent of the simulation method and software tool
    - **Agent-based simulation**, discrete-event simulation, system dynamics, …
  - Self-evolving V&V technique recommendation system

Proof of concept implementation so far



BOKEH Server Apps

- **Time series data visualization**
- **Trace data visualization/animation**
- **Network visualization**

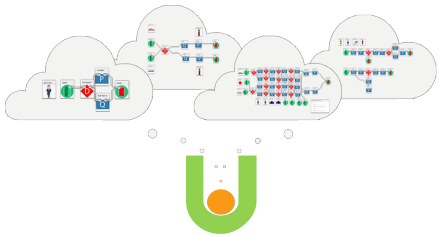
Roadmap (contingent on funding)

- **January 2020**
  - Kick off
- **2020**
  - Create basic V&V tools
    - User interface sketches and use-case diagrams for the selected techniques
    - Microservice implementation
  - Master Bokeh for creating custom V&V tools
  - Distributed database test and integration
  - Prototype user interface **(private alpha)**
- **2021**
  - Data management features
  - User management features **(private beta)**
  - Create more advanced V&V tools
  - Tool/library integrations
  - Orchestration **(public beta)**

Challenges

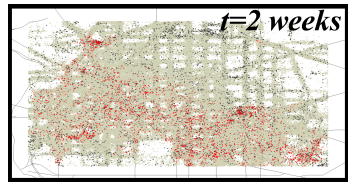
- Tool/library integrations
  - No standard in data collection methods
  - Making users minimally interrupted
- Auto-recognition of data types and important columns
- Computational (i.e., financial) cost

Implications for researchers



Improve V&V practices – moving the Modeling and Simulation field ahead

Exploration and validation of massive simulations (e.g., millions of agents)



The V&V recommendation system can change the way we conduct V&V

Seamless integration: third party service for cloud-based systems

INSIGHT MAKER

cloudes

HASH

References

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Thank you for listening!