The ADAPT Project: Adaptive and Autonomous Data Performance Connectivity and Decentralized Transport Decision-Making Network

MSc Vladislav Kashansky on behalf of ***ADAPT Collaboration***

vladislav.kashanskii@aau.at

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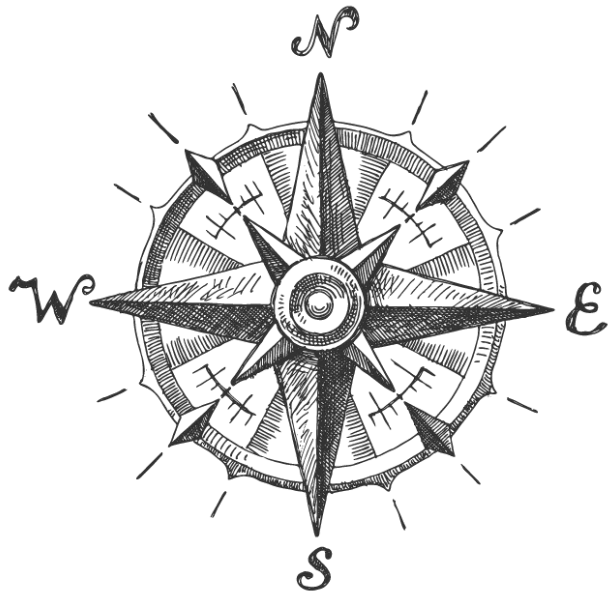
Presentation Outline

- ADAPT Project - Background Information;
- Challenges at the Large Scales – Multi-scale Systems;
- Blockchain Architecture & Formal Model;
- Q&A;



ADAPT Project

- The ADAPT project started during the most critical phase of the COVID-19 outbreak in Europe when the demand for Personal Protective Equipment (PPE) from each country's healthcare system surpassed national stock amounts.

- Due to national shutdowns, reduced transport logistics, and containment measures on the federal and provincial level, the authorities face new challenges to meet the quickly rising demands from national health care systems.

- Consortium & Partners:

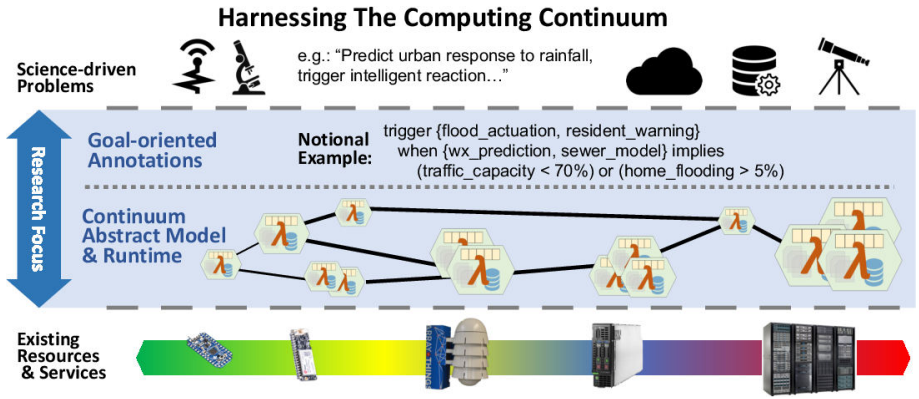
https://adapt-project.solutions/ - ***More Information***

ADAPT Project Objectives

- Architect and develop of the Blockchain solution as a Proof-of-Concept (PoC);
- Create a distributed and multi-scale logistic optimization system based on the PoC Blockchain;
- Evaluate the performance of the global PPE Supply Chain by verifying the ADAPT PoC functionality with selected stakeholders in a live-testing project phase.

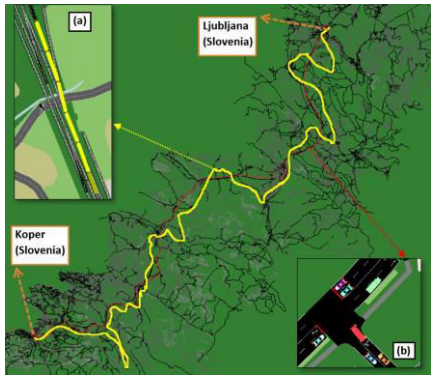
Computing Continuum – Multi-scale Dynamical Systems - Transport Networks

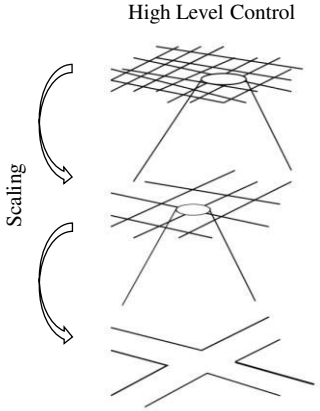
- Recent advancements in the field of parallel and distributed computing led to the definition of the **computing continuum** [1,2] as the environment comprising highly heterogeneous systems with dynamic spatio-temporal organizational structures, varying in-nature workloads, complex control hierarchies, governing computational clusters with multiple scales of the processing latencies, and diverse sets of the management policies.



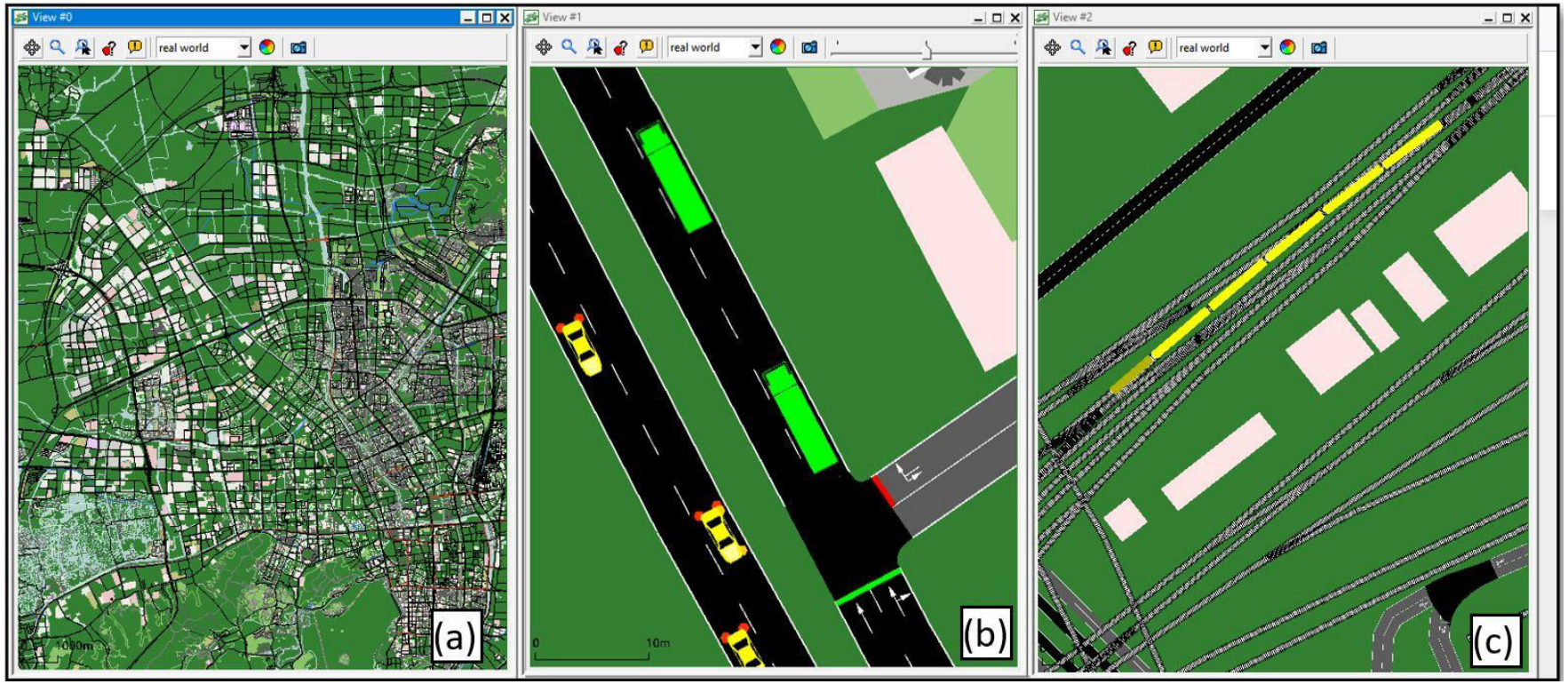
Beckman, P., Dongarra, J., Ferrier, N., Fox, G., Moore, T., Reed, D., & Beck, M. (2020). Harnessing the Computing Continuum for Programming Our World. *Fog Computing: Theory and Practice*, 215-230.

- **Examples:**
  - **social platforms** that analyze concurrently various motion patterns and opinion dynamics related to human behavior at various spatio-temporal scales;
  - self-organizing **vehicle fleets** and **drone swarms** that receive information from a large group of spatial sensors and need to make decisions locally.





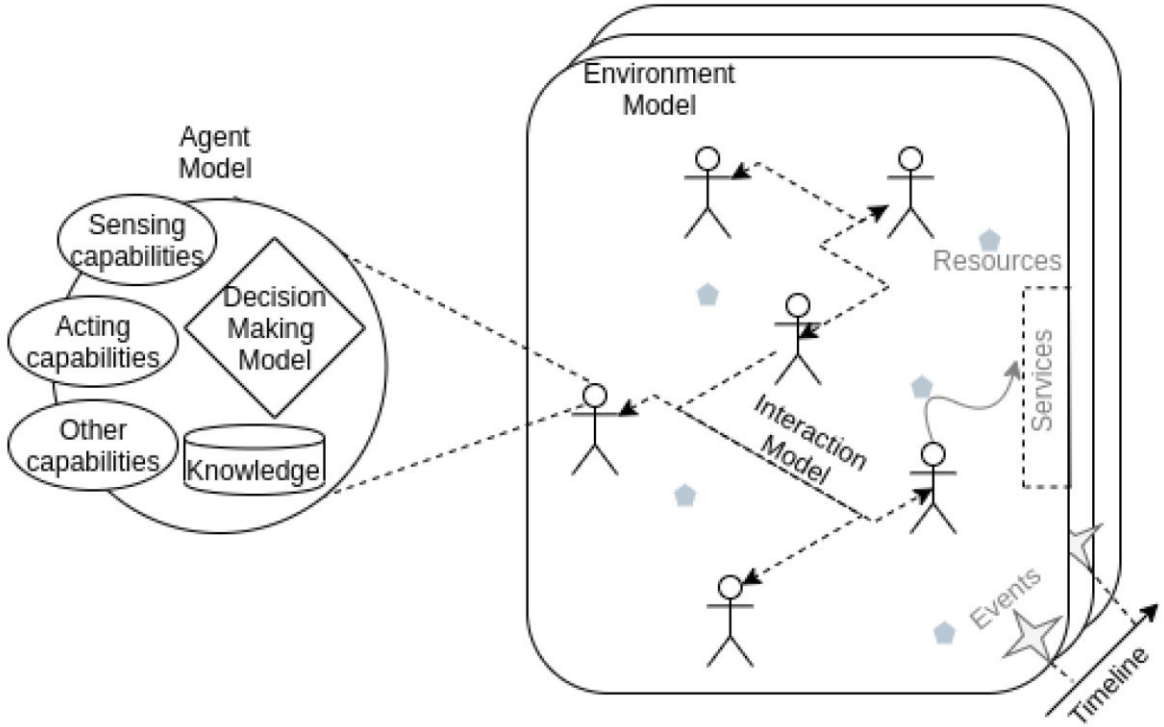
Transport Network Level Simulation – JKU Linz, Austira



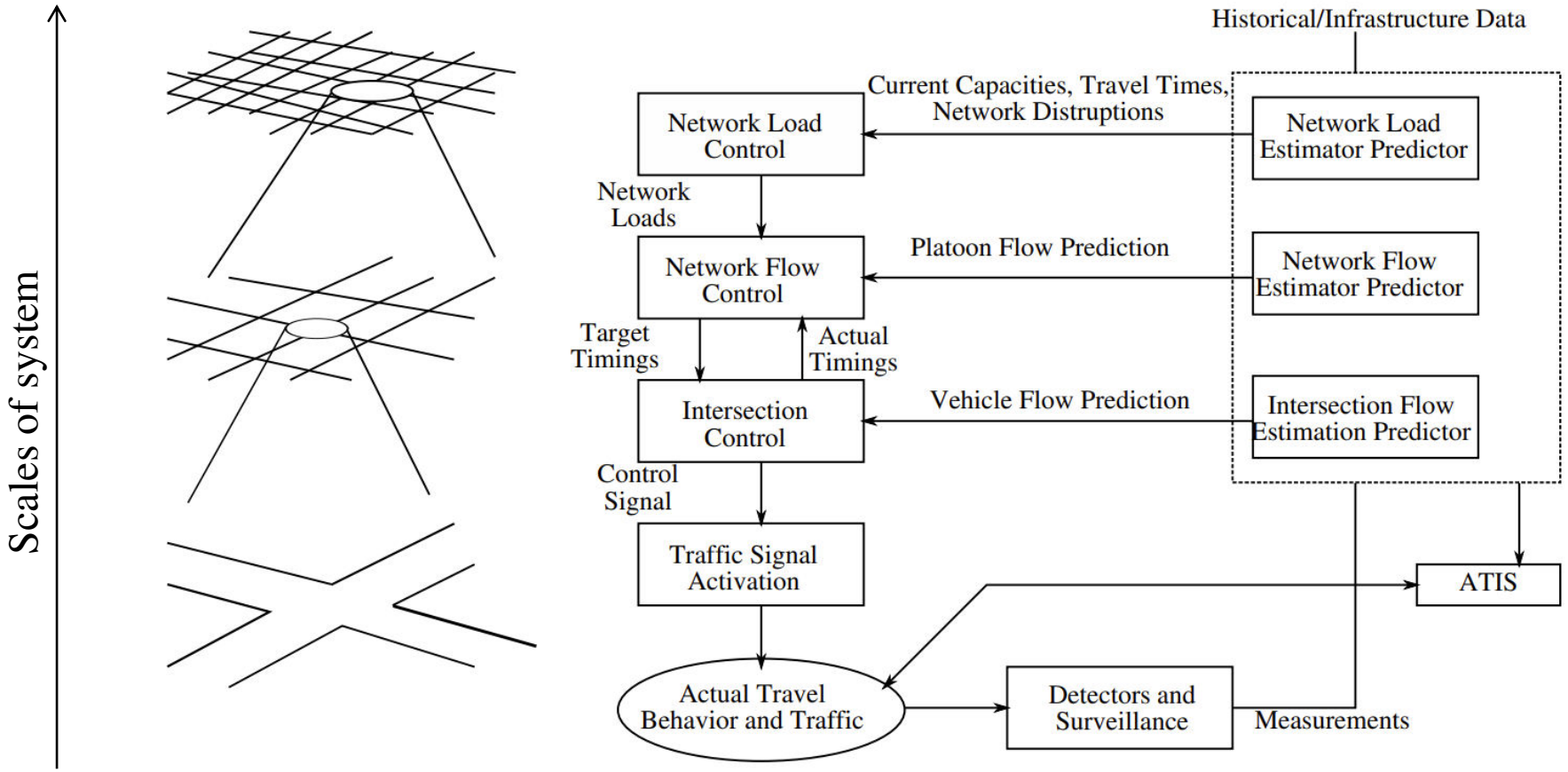
Validi, Aso, and Cristina Olaverri-Monreal. "Simulation-Based Impact of Connected Vehicles in Platooning Mode on Travel Time, Emissions and Fuel Consumption." *arXiv preprint arXiv:2105.10894* (2021).

Computing Continuum – Going Further

- Such networks consist of a large number of **locally interacting** agents that form stable emergent flows of data and execute arbitrary workloads.
- It is important to highlight that we are no longer dealing with machines in the case of computing continuum, but with agents capable of **consensus formation** of various kind.
- A key property typical to all sufficiently complex ecosystems is their tendency to grasp the sub-systems, provide uniformity over heterogeneity and optimize the endpoint workload execution in the presence of target criteria with system-wide constraints - **Blockchain**.



Hierarchical control systems (MPC) – RHODES Approach

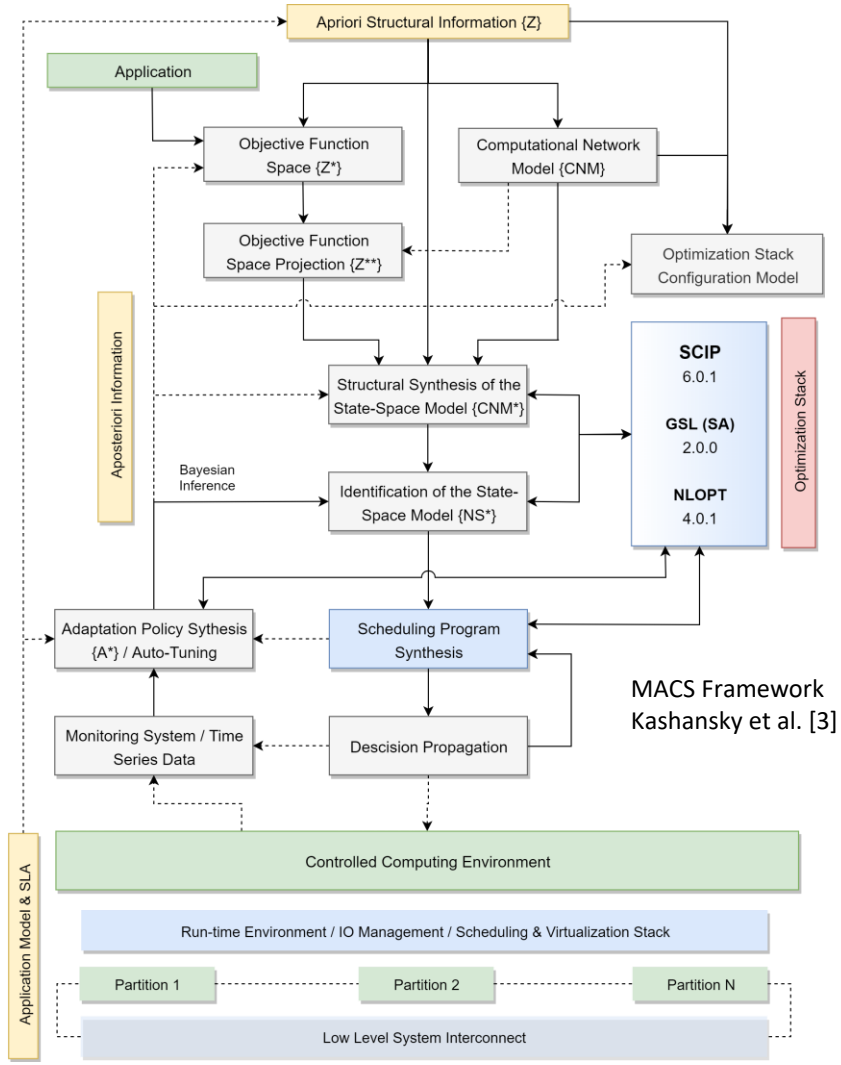


Mirchandani, Pitu, and Larry Head. "A real-time traffic signal control system: architecture, algorithms, and analysis." *Transportation Research Part C: Emerging Technologies* 9.6 (2001): 415-432.

MACS Framework - Control Algorithms - Networks, networks, networks …

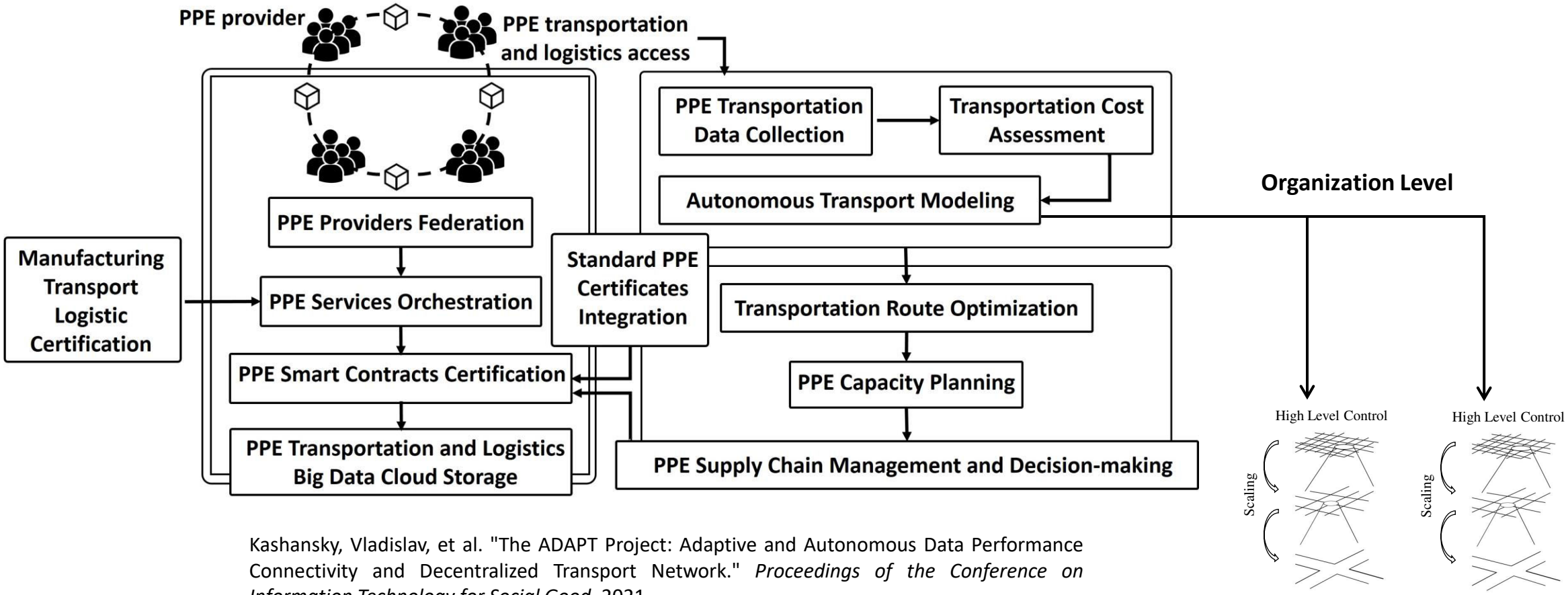
Scales	*Monitored system*	*Metrics*	*Latency*
Local urban level	Local self-organization (platooning)	Mostly sensors measurements: video, LiDAR, temperatures, GPS, fuel consumption	Sensitive, real-time data
Organization level	Data center (IaaS), Services (PaaS, SaaS)	CPU/RAM use, I/O latency heatmaps	Non-sensitive, coarse-grained statistics
Cross-organization level	Blockchain: hyperledger fabric	Adaptive profiling, failure monitoring, transaction rates	Non-sensitive, coarse-grained statistics

- **Computational network**, which provides ***structural*** knowledge about the possible information flows within the system and possible interactions of agents via adjacency matrix;
- **Recursive network,** which forms a multi-layer DAG and provides knowledge about non-equilibrium dynamic processes in the computational network. This component is optional and only required if behavior of the network is considered far from equilibrium. Examples include: **Dynamic Bayesian Networks** (DBN) and **Hidden Markov Models** (HMM);
- **Workload network** is the set of tasks, represented as the **DAG** that governs **mesoscopic** computational process in the computing continuum, prescribing **arrow of the time**.



MACS Framework
Kashansky et al. [3]

Cross Organization Level – Blockchain Network



Kashansky, Vladislav, et al. "The ADAPT Project: Adaptive and Autonomous Data Performance Connectivity and Decentralized Transport Network." *Proceedings of the Conference on Information Technology for Social Good*. 2021.

Conclusion and Future Work

- We have presented ADAPT Project and provided a preliminary analysis as well as architecture of the multi-scale control architecture;

- We have highlighted place and archtecture of the blockchain in the given cross-organizational control system;

- Future work:
  - **Exact Smart Contract Semantics and Consensus Algorithms Analysis;**
  - **Finite prototype architecture;**
  - **Specific algorithms for OpenMP and OpenMPI techniques to speed-up computations;**
  - **Large-scale simulations requre non-trivial GPU acceleration techniques;**
  - **We expect to carry out more detailed comparative study of the several heuristics and decomposition methods;**

Thank you!

Q&A, Partnership:

radu.prodan@aau.at – ***Project Coordinator***

vladislav.kashanskii@aau.at – ***Scientific Coordinator***

References

- [1] Beckman, P., Dongarra, J., Ferrier, N., Fox, G., Moore, T., Reed, D., & Beck, M. (2020). Harnessing the Computing Continuum for Programming Our World. Fog Computing: Theory and Practice, 215-230.

- [2] Kashansky, V., Radchenko, G. and Prodan, R., 2021, June. Monte Carlo Approach to the Computational Capacities Analysis of the Computing Continuum. In *International Conference on Computational Science* (pp. 779-793). Springer, Cham.

- [3] Kashansky, V. et al.: MACS: Modular architecture for complex computing systems analysis. http://www.edmware.org/macs/, Accessed 29 Jan 2021