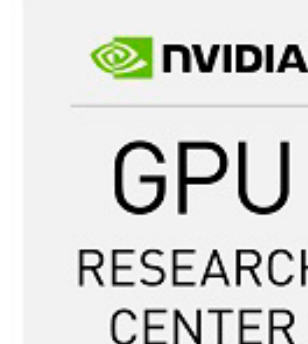


Accelerated Transport System Simulation using CUDA

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Transport System Simulation

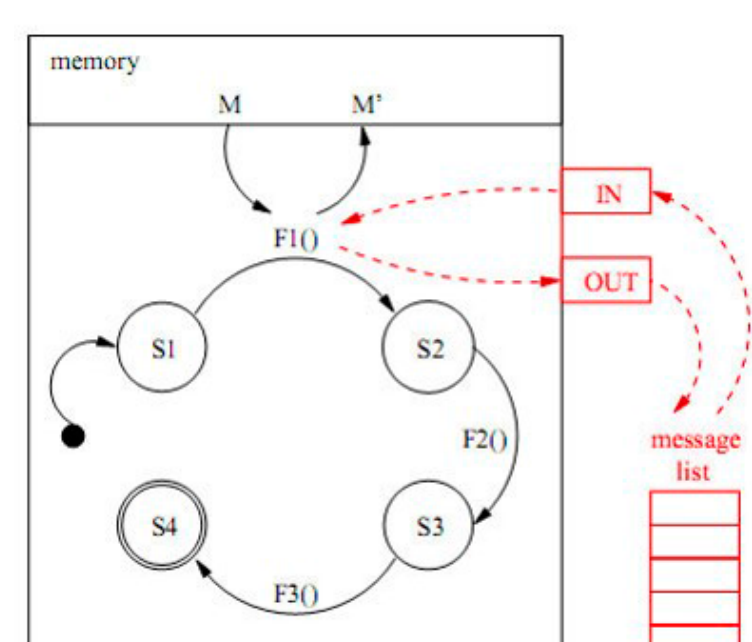
- Globally increasing demand on transport systems [1]
- Need for improved road simulation systems for planning and management [2]
- Microscopic (bottom-up) simulations becoming dominant in transport modelling, but are computationally expensive
- Agent Based Modelling (ABM) provides natural method for describing behaviour
- Must be accurate, scalable and simulate faster than real-time
- GPU acceleration can provide required performance

FLAME GPU

- Flexible Large-scale Agent Modelling Environment for the GPU
- Template-based simulation environment for high performance simulations [3]
- Agents represented as X-Machines with message lists for communication
- Message lists can be partitioned for increased performance
- Provides a high level interface for describing agents, abstracting the CUDA programming model [4]



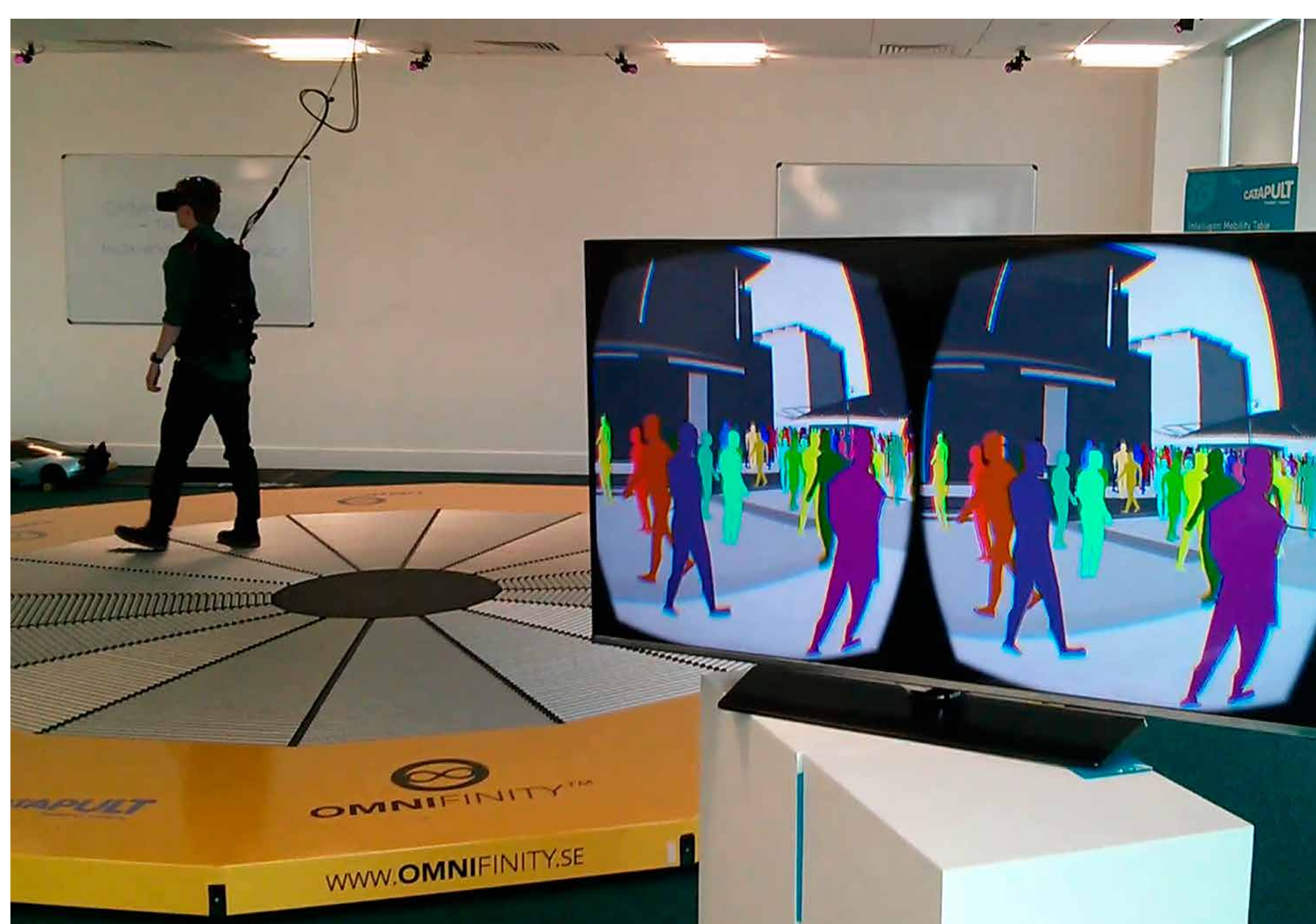
www.flamegpu.com



X-Machine Diagram

Virtual Reality Pedestrian Simulation

- Omnidirectional treadmill (Omnifinity Omnidock6) and Oculus Rift used to provide a highly immersive VR environment
- Virtual environment populated with crowd of simulated pedestrians exhibiting realistic behaviour
- Pedestrians avoid each other, their environment and the user
- Allows urban designers to experience their creations populated with large crowds of pedestrians
- High performance simulation and efficient rendering to achieve required frame rate



- FLAME GPU enables simulation of thousands of pedestrians in real-time using the GPU
- CUDA OpenGL Interoperability [5] and Geometry Instancing [6] used to efficiently render large population of individuals

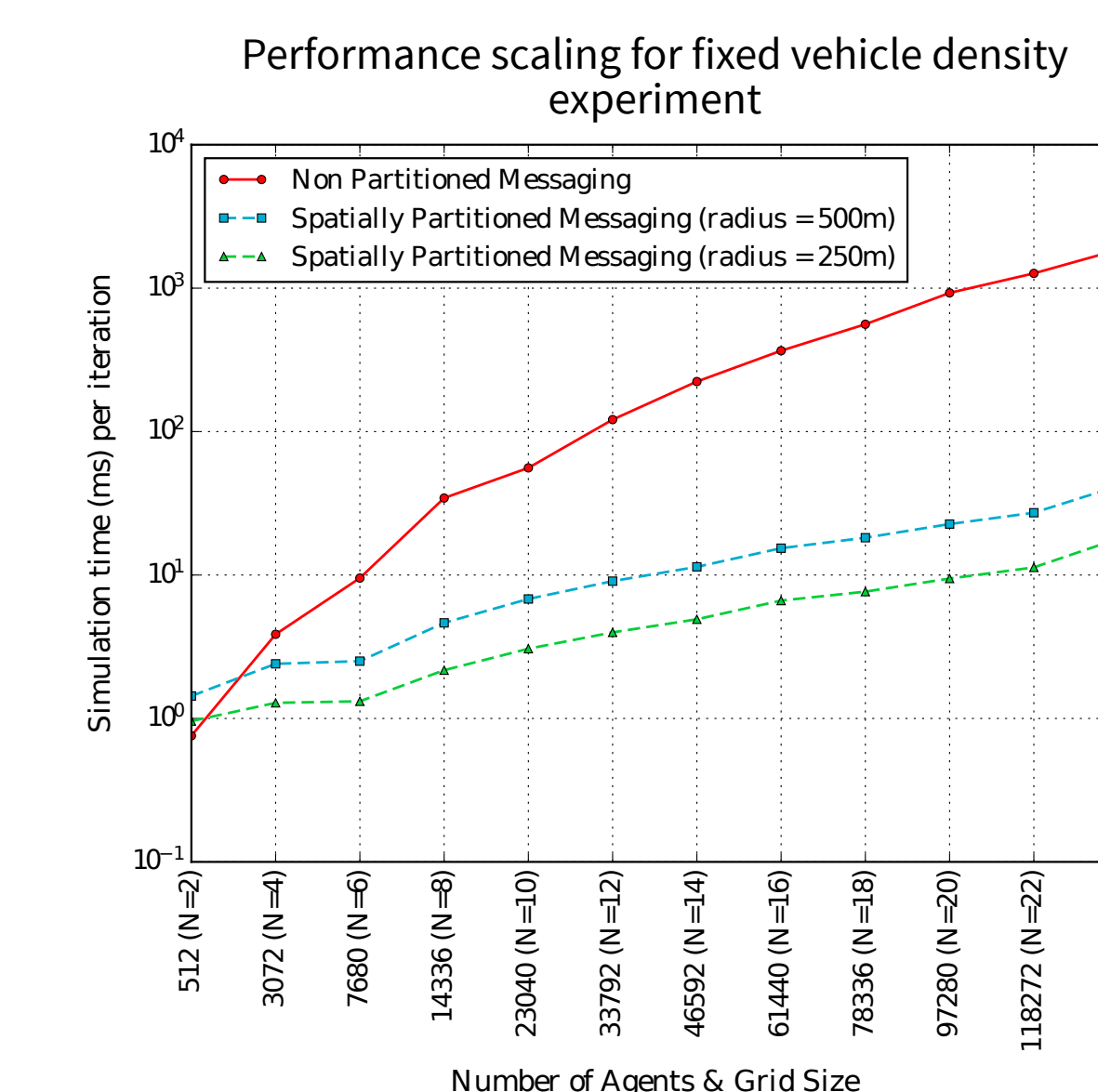
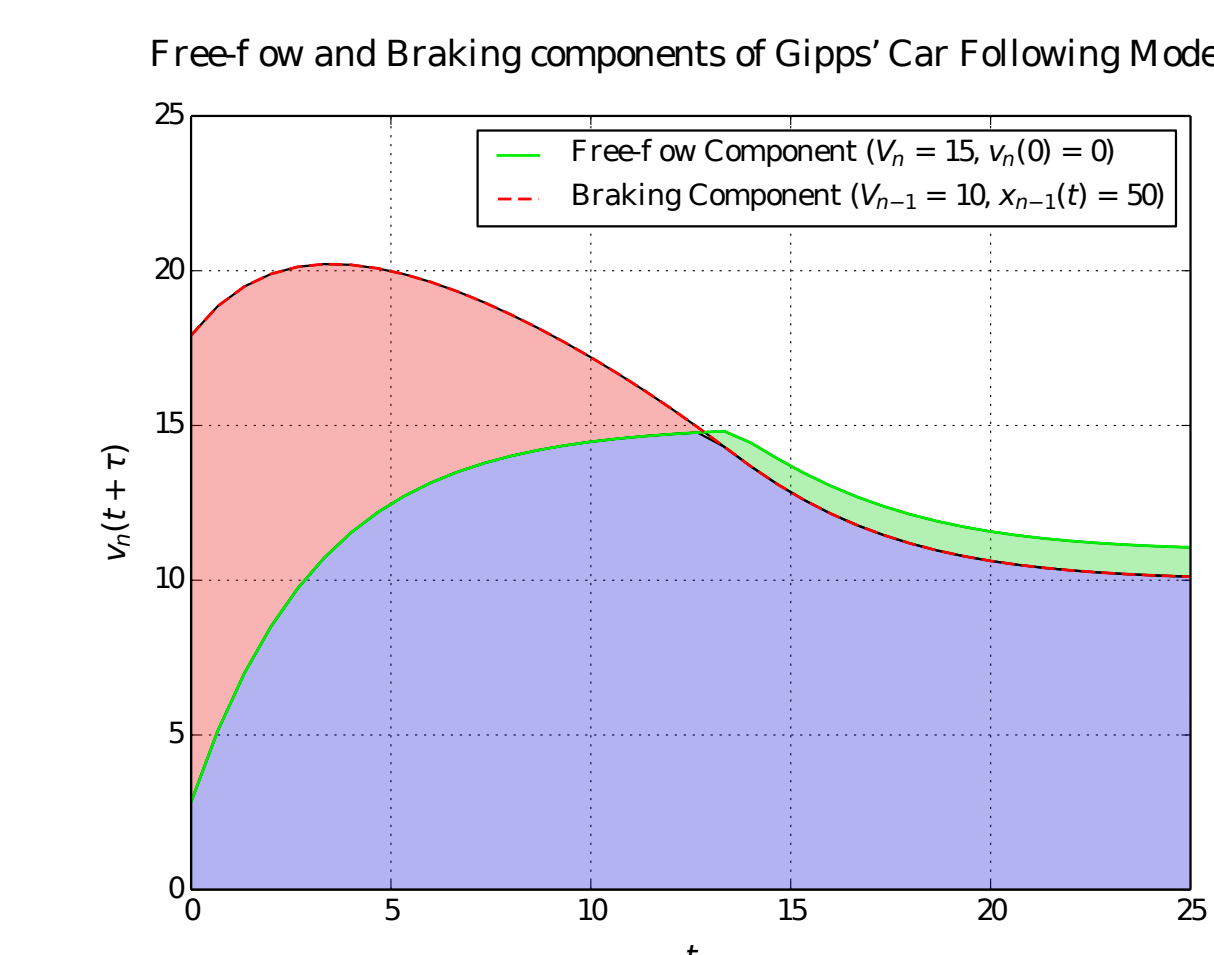
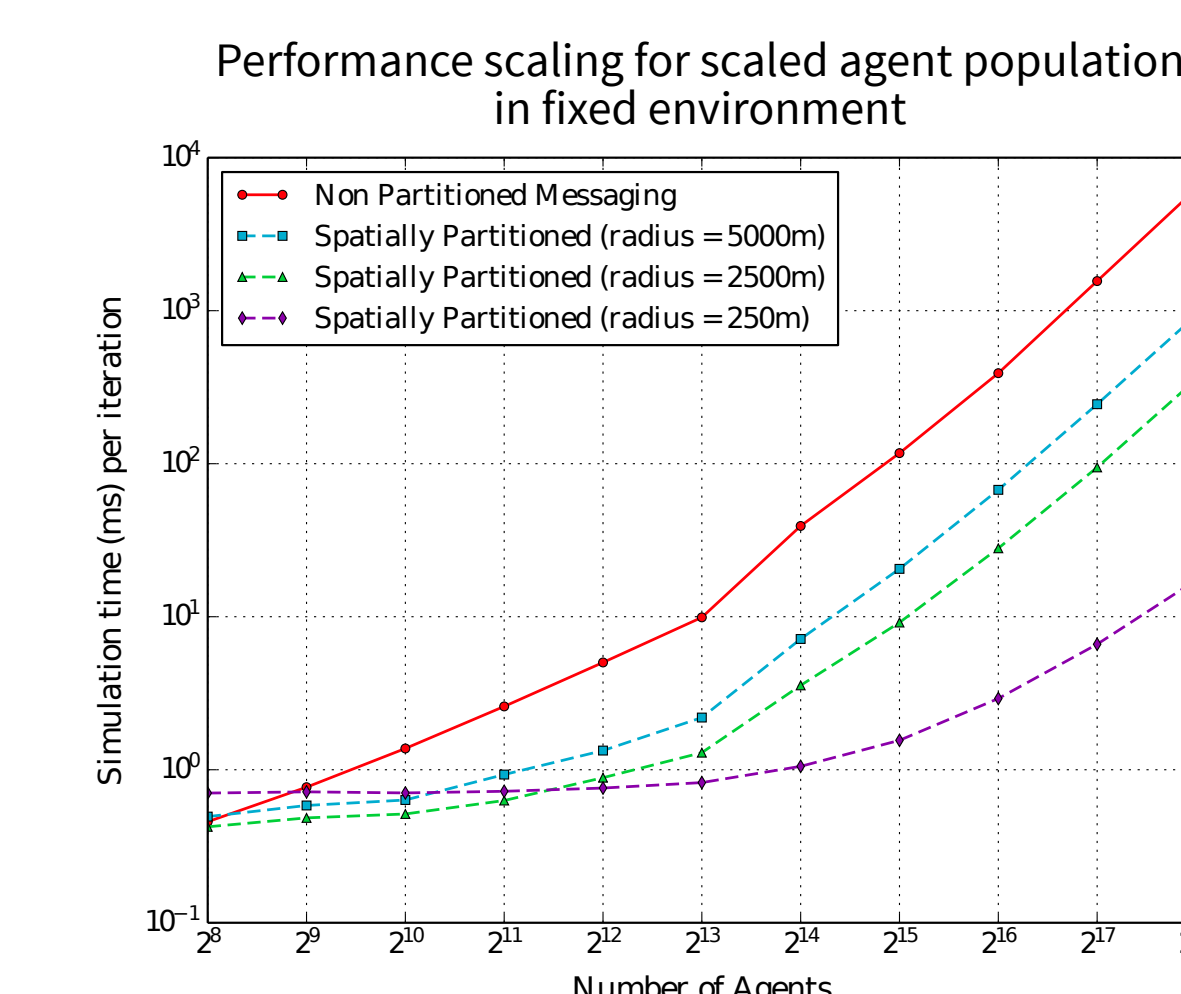
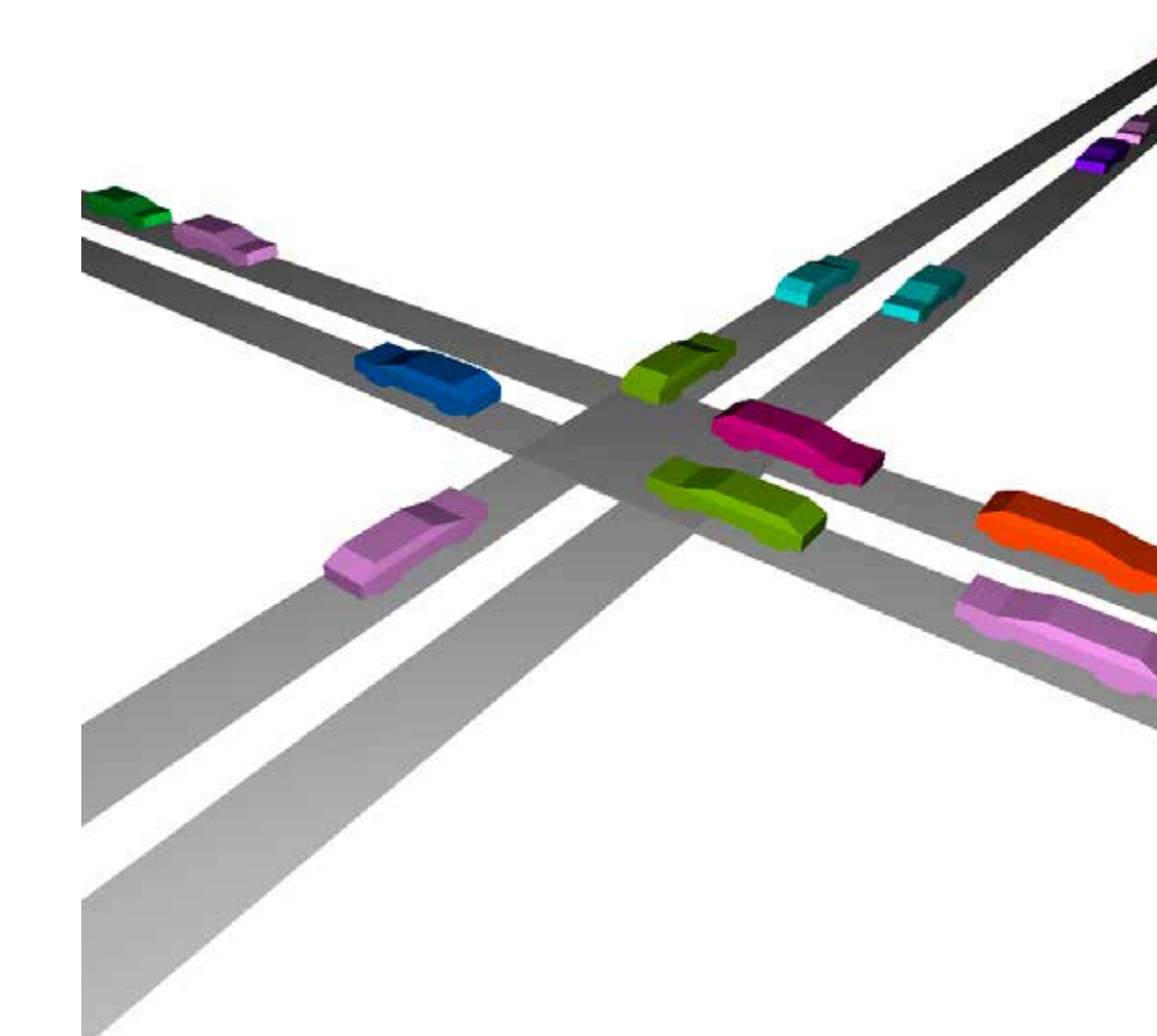
Transport Systems Catapult

- The Transport Systems Catapult is one of seven elite technology and innovation centres established and overseen by the UK's innovation agency, Innovate UK.
- Use new and emerging technologies to transport people and goods more smartly and efficiently.
- Includes "Visualisation Laboratory" where virtual reality technology will be used to help generate innovation and overcome problems in the UK's transport network.
- <http://ts.catapult.org.uk>



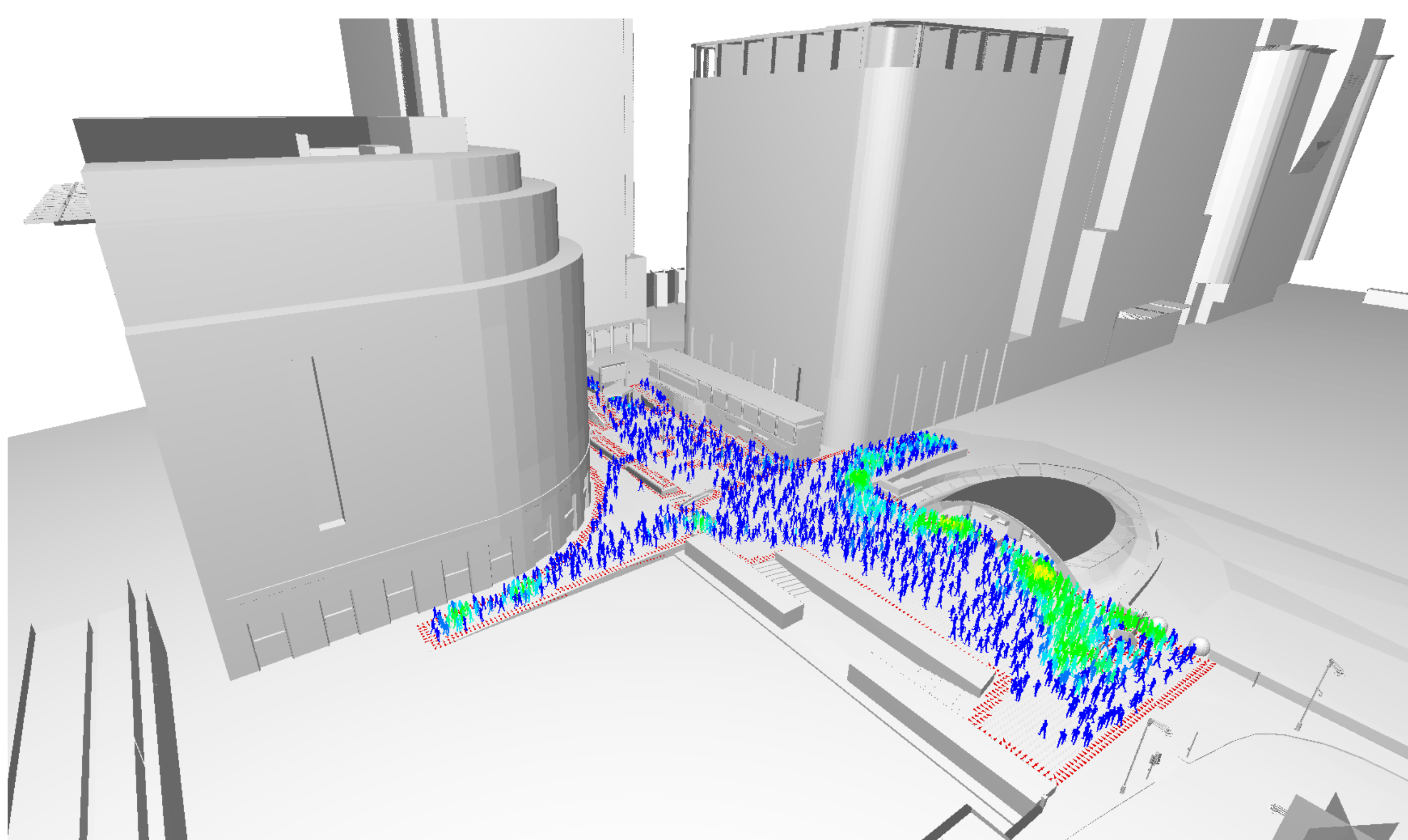
Road Network Simulation using FLAMEGPU

- Artificial road network used to test scalability of FLAME GPU for simulating large-scale road networks [7]
- Car following behaviour implemented (Gipps' car following model [8])
- Safety-distance model considers driver and vehicle characteristics
- Message partitioning scheme can significantly effect performance at large scale
- Real-time rendering enabled by geometry instancing allows for increased accessibility to non-specialists
- Benchmarked using nvidia Tesla K20c



References

[1] Department for Transport: Road traffic forecasts 2015. Mar. 2015
 [2] Neffendorf H., Fletcher G., North R., Worsley T., Bradley R.: Modelling for intelligent mobility. Feb. 2015
 [3] Richmond P.: FLAME GPU technical report and user guide. Tech. rep., technical report CS-11-03. Technical report, University of Sheffield, Department of Computer Science, 2011.
 [4] Richmond P.: Resolving conflicts between multiple competing agents in parallel simulations. In Euro-Par 2014: Parallel Processing Workshops vol. 8805 of Lecture Notes in Computer Science. Springer International Publishing, 2014, pp. 383–394.
 [5] Nvidia C.: Cuda c programming guide. http://docs.nvidia.com/cuda/pdf/CUDA_C_Programming_Guide.pdf, Mar. 2015.
 [6] Khronos Group: OpenGL SDK glDrawArraysInstanced. <https://www.opengl.org/sdk/docs/man/html/glDrawArraysInstanced.xhtml>.
 [7] Heywood P., Richmond P., Maddock S.: Road Network Simulation using FLAME GPU. In Euro-Par 2015: Parallel Processing Workshops, Lecture Notes in Computer Science. 2015.
 [8] Gipps P. G.: A behavioural car-following model for computer simulation. Transportation Research Part B: Methodological 15, 2 (1981), 105–111.



Pedestrian Crowd simulation of central London