

3D Visualization of Computer System Architecture for Performance Analysis and Education

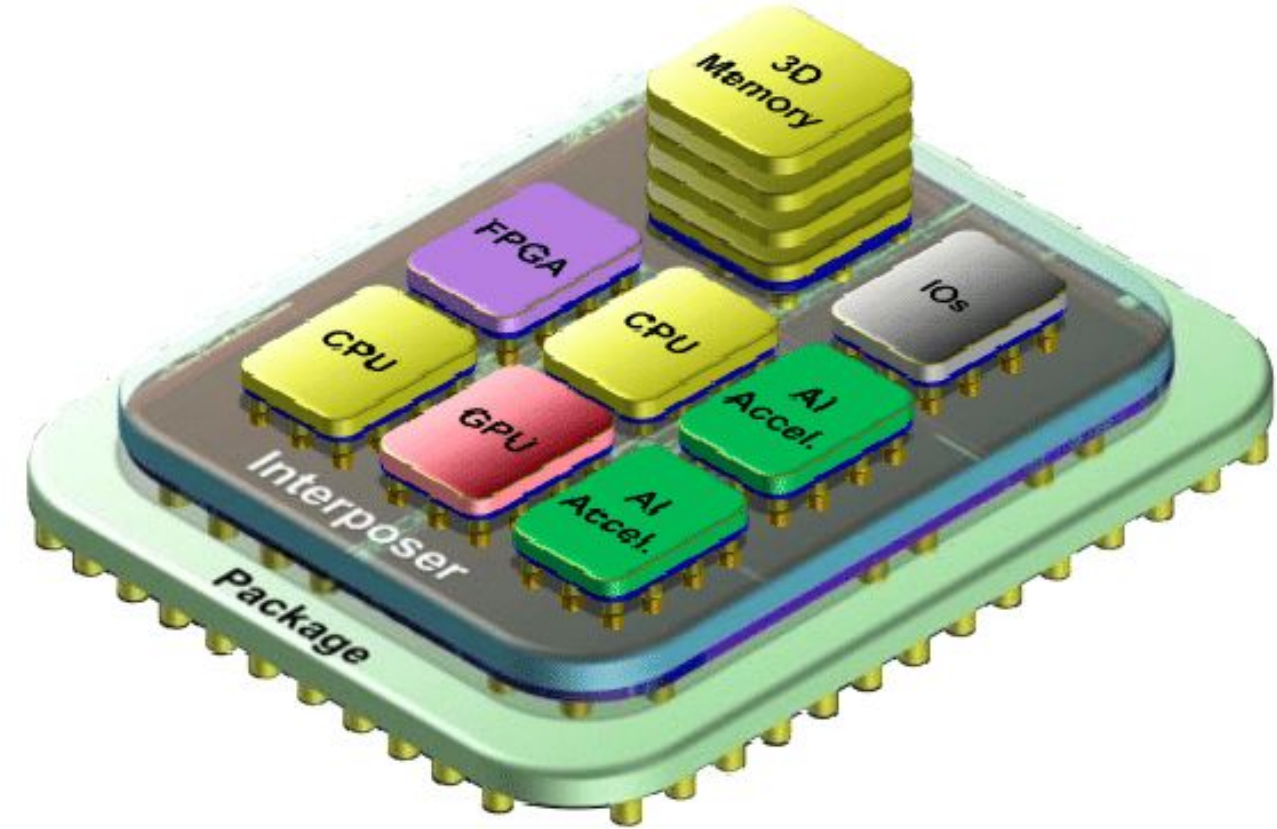
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Introduction

- Computer system architectures are organizations of hardware and software
 - Emerging xPU and heterogeneous systems are using 3D chiplet and stacked architectures



Example of chiplet architecture

- However, computer system architectures are complex and difficult to understand
 - Hence, visualization will help better educate and communicate with individuals who lack technical knowledge of such topics
- 3D visualization also has the potential to be more effective than traditional 2D visualization
 - 3D Visualization can explore new performance analysis techniques in areas such as parallel processing
 - Existing educational diagrams and visualization of computer architectures are limited to 2D

Objectives

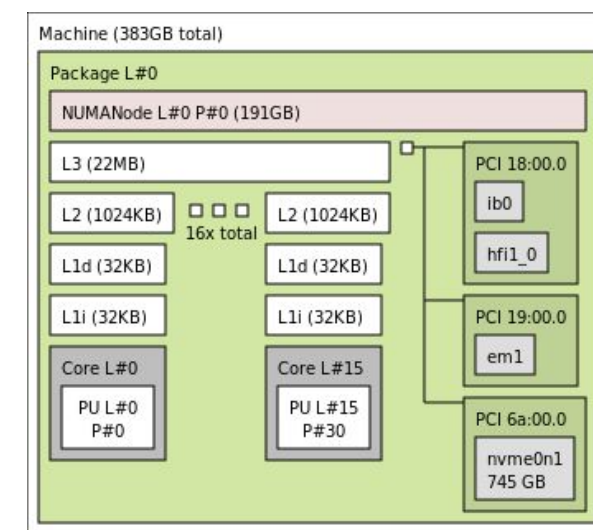
- This research aims to use a novel approach to visualize computer components, memory hierarchy, and interconnecting bus architecture in 3D space
- Emphasis is placed on visualizing the hierarchical relationship between components in the system architecture
- Exploring 3D visualization can produce effective learning tools for students and professionals alike

Method

HWLOC

Makes use of Portable Hardware Locality (HWLOC) architecture, a software that provides the hierarchy of computer architectures

- Represents the topology as an XML
- Models the topology in 2D



Example HWLOC graphical output

Unmarshal

Retrieves data from the topology XML by unmarshalling into Java content using JAXB

- Accesses Java content as an object for for visualization

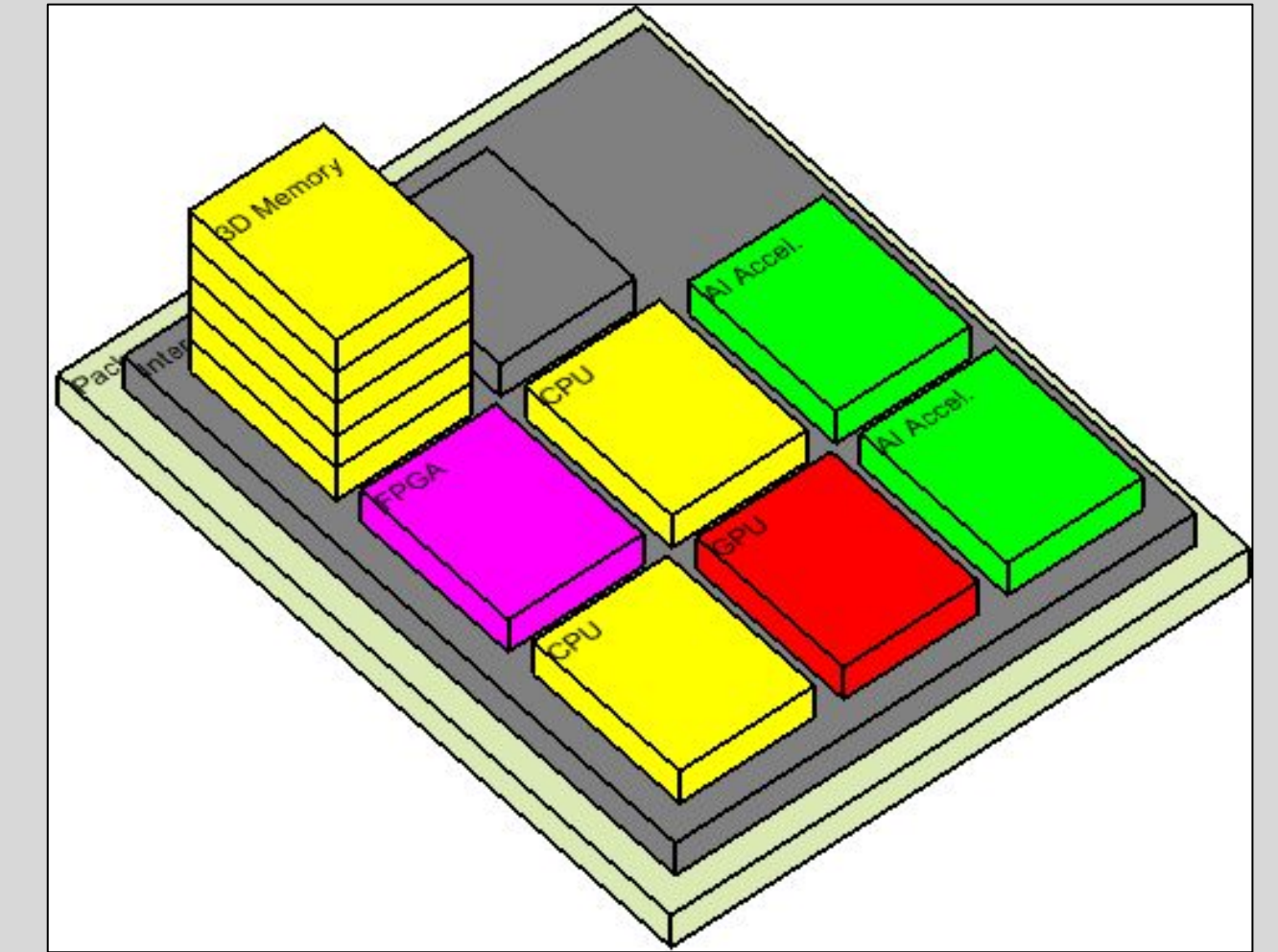
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```

Example topology XML

Visualize

Visualizes the topology in 3D with OpenGL using Java-OpenGL binding library JZY3D/JOGL

- Recursively traverses the nested structure of the computer system architecture represented as an object to allocate 3D space for each component
- Draws the shapes for each component of the hardware architecture
- Gets class attributes to label components



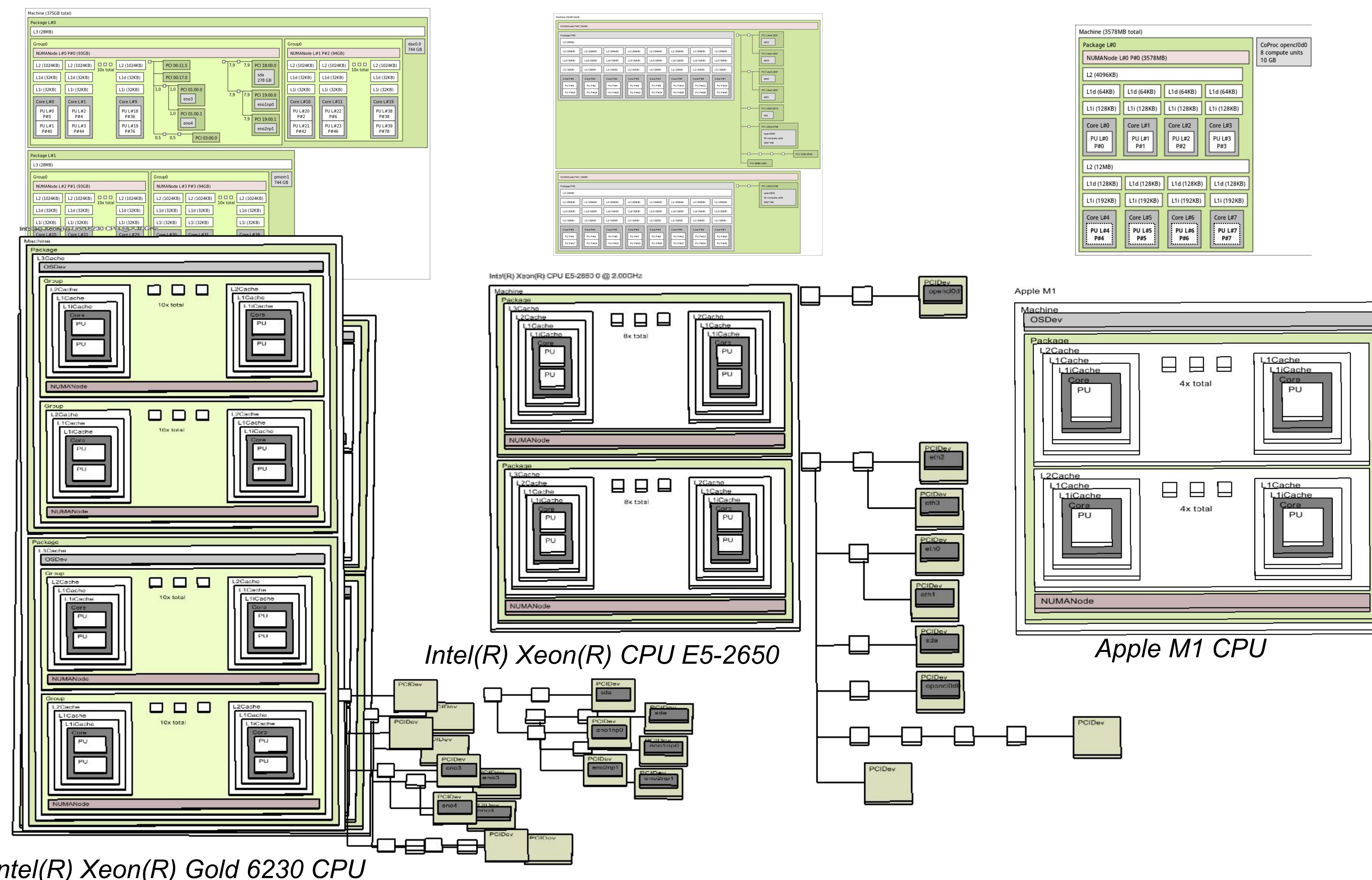
Experimental model of chiplet architecture

Conclusions

- This research studies hierarchical computer system architectures as tree data types using topologies provided by HWLOC
- Introducing 3D visualization of computer architecture can bridge the gap between theoretical knowledge and practical application of computer architecture education
- Users can gain a deeper understanding of both the high-level and low-level architecture depending on their needs

Results

3D visualizations of CPU architectures with their 2D HWLOC counterparts



Future Plans

- Extend HWLOC2.DTD or other XML-based hardware description languages to specify chiplet architecture
 - Research chiplet integration languages such as 3dblox and CDXML
- Visualize layers of complexity by allowing users to zoom in to see greater detail within the system architecture

References

- French, D. J., Stone, B., Nysetvold, T. T., Hepworth, A., and Edward Red, W. (May 3, 2016). "Collaborative Design Principles From Minecraft With Applications to Multi-User Computer-Aided Design." ASME. J. Comput. Inf. Sci. Eng. June 2016; 16(2): 021006. <https://doi.org/10.1115/1.4032667>
- Cecile Yehzekel, Mordechai Ben-Ari & Tommy Dreyfus (2007) The contribution of visualization to learning computer architecture, Computer Science Education, 17:2, 117-127, DOI: [10.1080/08993400601165545](https://doi.org/10.1080/08993400601165545)