PFI:BIC Next Generation Real-Time Distributed Manufacturing Service Systems Using Digital Process Planning and GPU-Accelerated Parallel Computing (Award #1631803)

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Lineage: 2013 (ENG/CMMI #1329742) est. process planning and computing, 2015 (ENG/CMMI # 1547093) expanded to education and design innovation, PFI:BIC expands to a service platform, and examines human factors and representation of tasks

TuckerInnovations   Morris OKUMA   NCDMM   DMDII   ncms   Mazak

Problem: High Cost of Adv. Manufacture

Design organizations and new entrepreneurs have limited access to the advanced manufacturing processes needed for innovation due to:
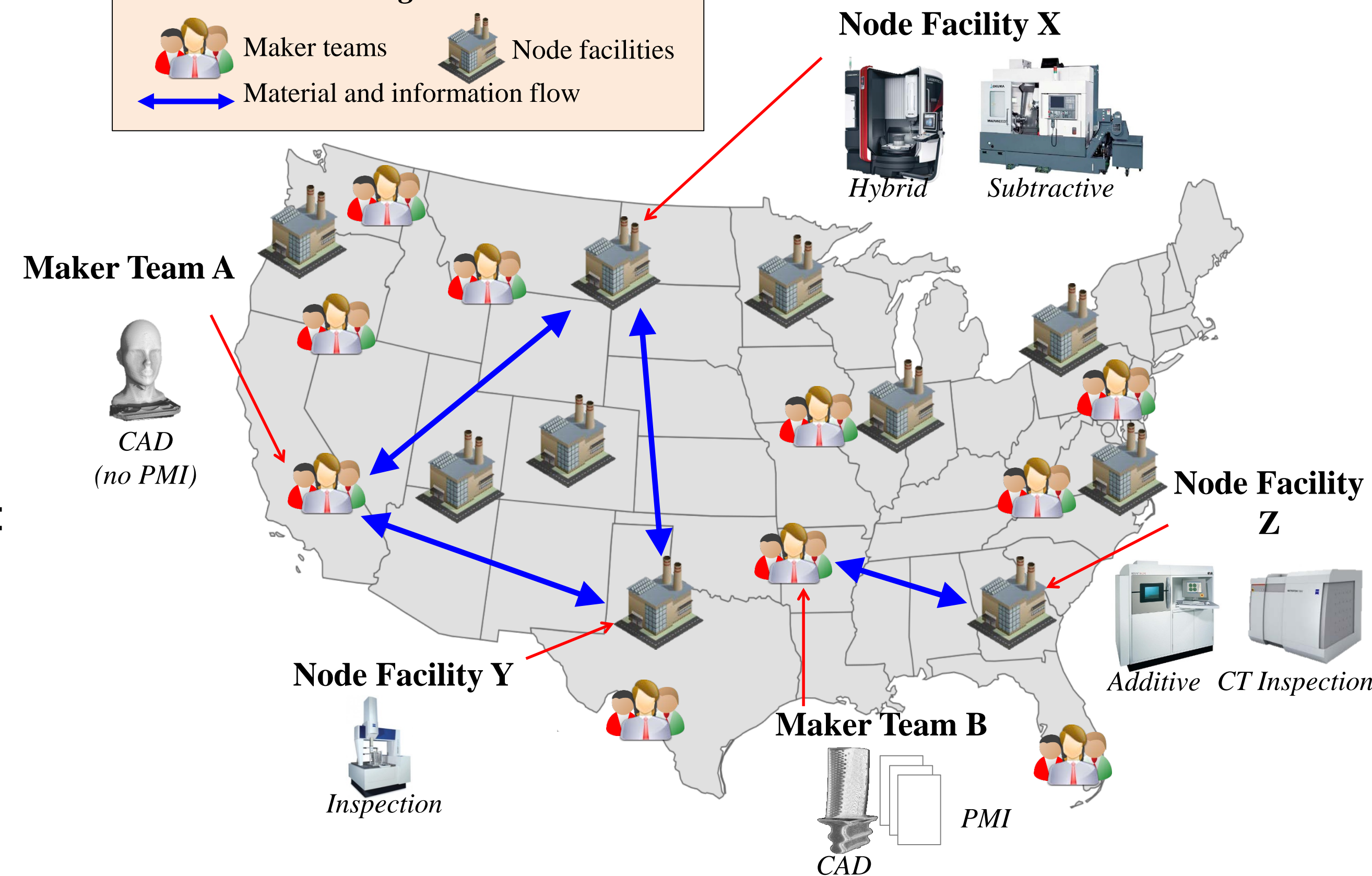
- Financial barriers
- Technical skill barriers
- Communication barriers
- Motivation mismatches
- Time constraints'
- Lack of computing resources

Higher access to advanced manufacturing can:

- Accelerate product development
- Enable non-traditional innovators
- Stabilize demand for producers
- Expand customer base for manufacturers

Solution: Democratization of Manufacturing through a Smart, Human-Centered Service System

The MakeStore Design Innovation Cloud
Maker teams   Node facilities
Material and information flow

Node Facility X
Hybrid   *Subtractive*

Maker Team A
CAD (no PMI)

Node Facility Z
Additive   *CT Inspection*

Node Facility Y
Inspection

Maker Team B
CAD   *PMI*

Our solution uses cloud computing to scale a novel, voxel-based manufacturing analysis in a smart, human-centered, manufacturing service system.

Features:

- Ease of 3D printing, precision of machining
- Usable by novice designers and innovators
- Handles complex geometries
- Real-time connection between designer and manufacturer
- Resolves communication and knowledge barriers
- Provides design and manufacturing feedback
- Accurate specification of part requirements
- Novel hybrid dynamic tree representations
- Graphics processing unit (GPU) accelerated parallel computing
- Advanced, automatic toolpath assessment

Manufacturing, design, computing and psychology help bridge the divide between makers (novice designers) and manufacturers (producers)
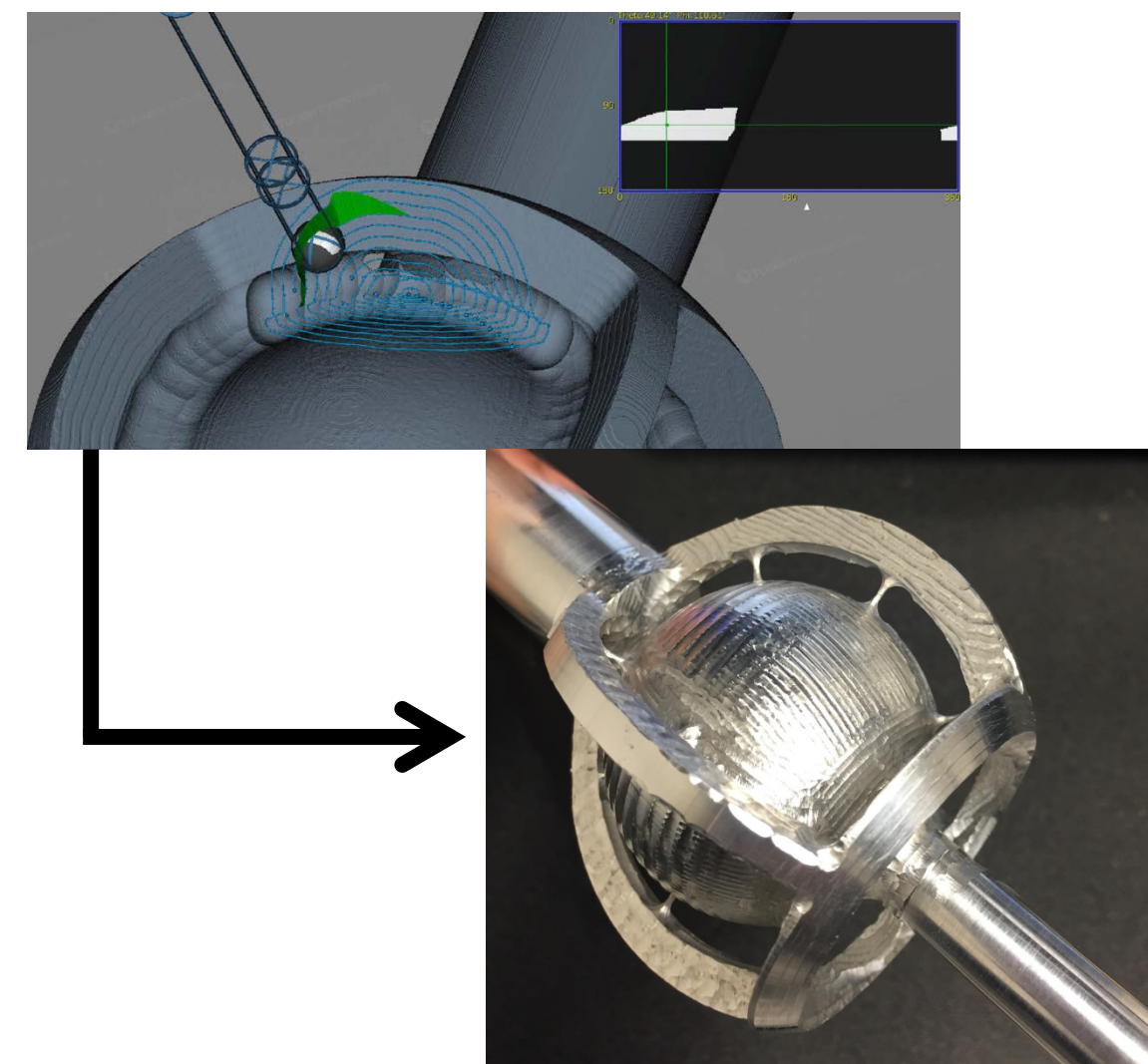
SculptPrint Software: The Print Button for 5-axis CNC Machining

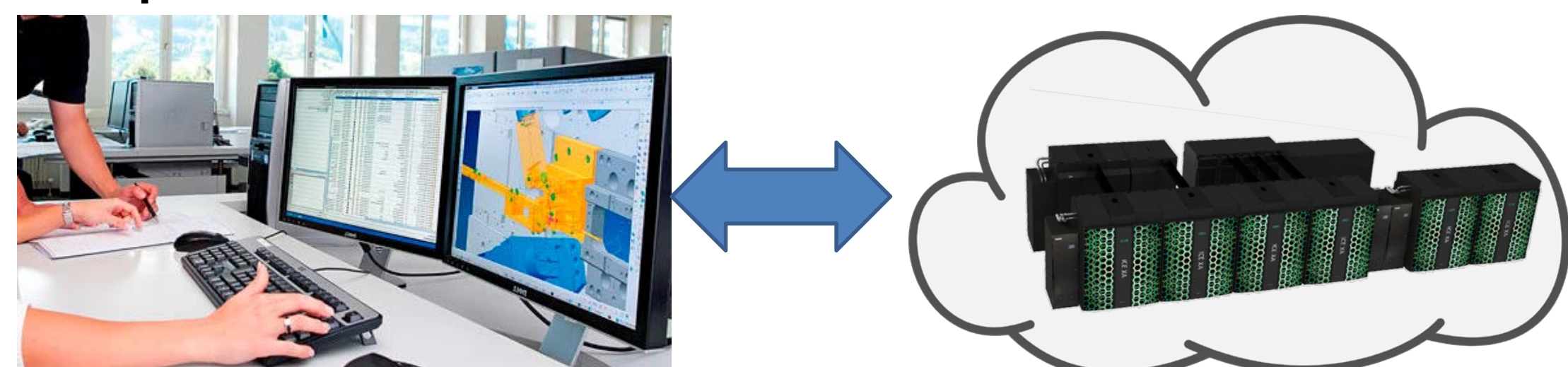**Discrete Geometry Representation for Computer-Aided Manufacturing**

- 3D Pixels
- Alternative to B-rep or CSG

Input Mesh (STL)   →   Voxelized Model
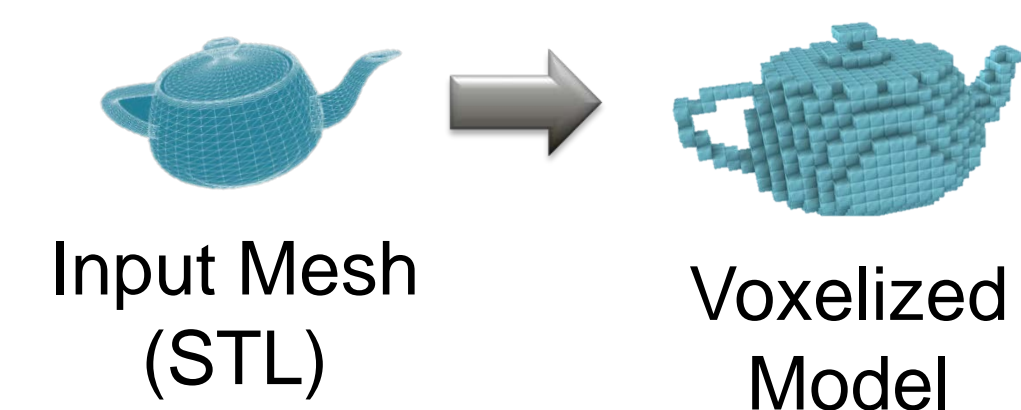
Complex Toolpath Automation

**Clould-based Distributed-Memory GPU Compute Clusters**

Year 1 Testing and Success:

- Tested computational algorithms and software interface in a many-user, cloud-based environment
- Prototyped several computations (geometric boolean editing, offsetting, access mapping) for distributed CPUs (built on top of p4est and MPI libraries).
- Interviewed expert machinists and performed tests with novices (usability and workload surveys)
- Multi-dimensional scaling study of novice and expert cognitive dimensions revealed disparate mental spaces for artifacts
- Expanded intelligent tooling and manufacturability analysis
- Created single-step toolpaths for complex artifacts

Makers and potential customers for manufacturers

Rather than just create a new tool (automation), we combine human factors with manufacturability and computing techniques to change the representation of tasks.
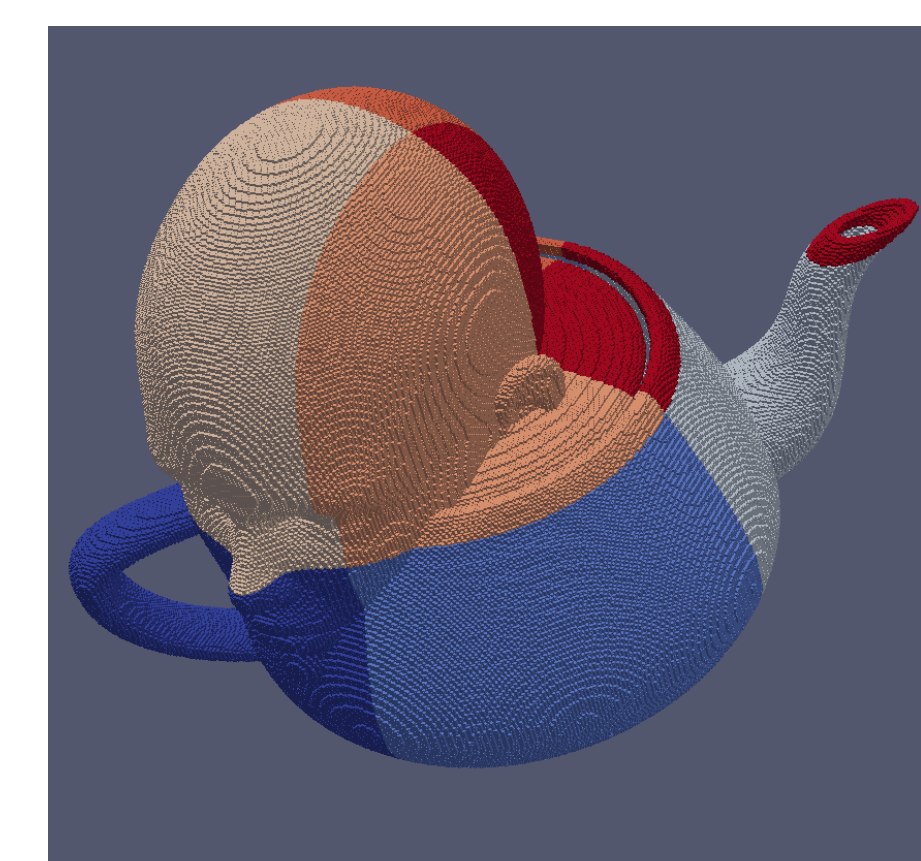
SculptPrint transforms CAD to voxel representation and creates partitions (here, into 8 such partitions) that may then be distributed across multiple nodes of a compute cluster.

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