The Printer Working Group

3D Printing BOF

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PWG F2F Meeting

Camas, WA

Michael Sweet (Apple)

BOF Agenda

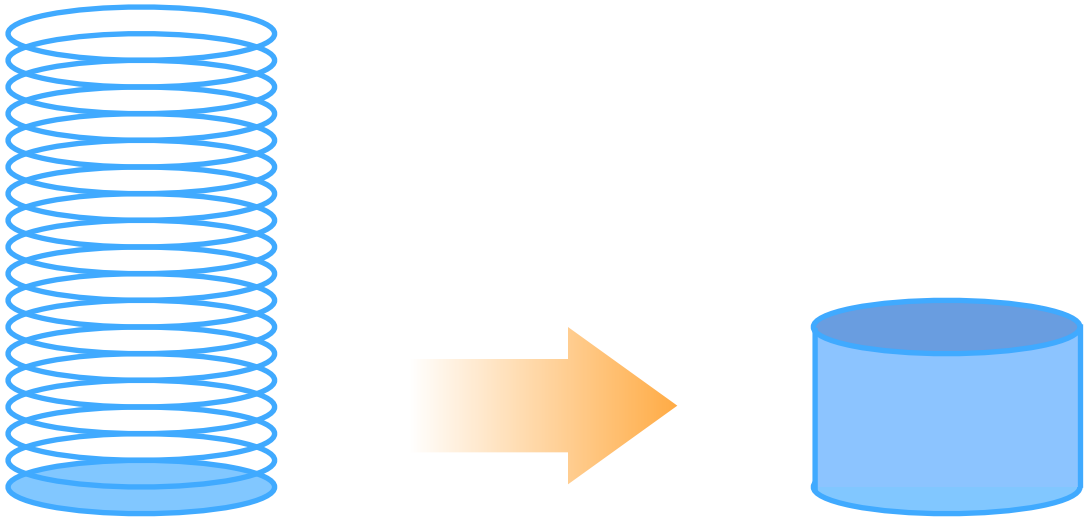
- Scoping/use cases
- Review: 3D printing extensions for the Internet Printing Protocol (IPP)
- Next steps

Background/Resources

- "3D Printing" is generally Additive Manufacturing (adding material to make a three dimensional object)
  - Subtractive Manufacturing (milling, grinding, etc.) is also applicable, and there are hybrid solutions that use both
- Useful web pages on 3D printing:
  - http://3dprintingindustry.com/3d-printing-basics-free-beginners-guide/
  - http://en.wikipedia.org/wiki/3D_printing
- Semantic Model:
  - http://www.pwg.org/sm
- Internet Printing Protocol (IPP):
  - http://www.pwg.org/ipp
- Past 3D Printing BOFs:
  - http://www.pwg.org/bofs.html

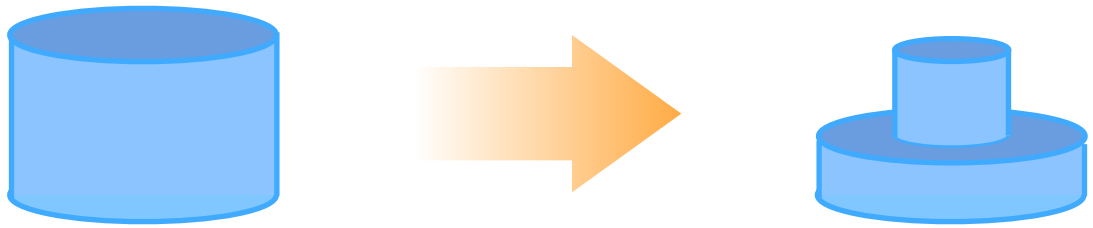
Additive Manufacturing

- In Additive Manufacturing, material is added to form three-dimensional objects, typically in deposited horizontal layers:



Subtractive Manufacturing

- In Subtractive Manufacturing, material is removed to form the final three-dimensional objects:



Scoping/Use Cases

- From prior BOFs:
  - Stick with "personal manufacturing" class of products plus cloud solutions for now
  - Focus on higher-level document formats, since G-code can be too printer/material-specific and common SoC implementations have the memory and CPU needed to do slicing already
    - Still provide lower-level material/state information
    - Material information still needs to be specified in job ticket (at a minimum: outer "shell" materials, in-fill materials, and support materials)
  - Cloud-based solutions can take advantage of IPP Shared Infrastructure Extensions
    - Remote camera feeds can be supported by uploading snapshots - needs some prototyping to determine feasibility/performance constraints

IPP 3D Printing Extensions

- Current draft (white paper):
  - http://ftp.pwg.org/pub/pwg/BOFs/3d-printing/wd-apple-ipp3d-20150729.pdf
- Issues:
  - Need a lot more definitions for materials
  - Need a way to associate materials in the job ticket to those in the document data (next slide)
  - Anything more needed to support paid 3D printing solutions?

Materials

- Existing file formats lack good material intent support:
  - AMF support a single named material per "volume" (a closed space, all or part of the printed object) with an RGB color value and some physical characteristics (but not the material type)
  - Collada (DAE) files support color and texture but not named materials
  - STL does not support a way to specify materials
- "New" 3MF Consortium file format isn't any better
  - http://www.3mf.io/what-is-3mf/3mf-specification/
    - Same as Microsoft's 3DMF format from a few years ago
  - Uses OPC (ZIP container) which makes streaming problematic, increases storage and CPU overhead on printer
  - Job ticket is embedded in file
  - Material support limited - names and sRGB colors

Materials

- Multiple-material printers are becoming more common, but still largely experimental due to difficulty supplying document data expressing the material requirements
  - Multiple files, one per material, are often used for FDM printers but this does not scale
  - Users asking for the ability to use different materials for in-fill and supports, e.g., Red PLA on the outside, white/natural PLA on the inside, and dissolvable filament for the supports.
- Named/numbered material association in the document is fairly straight-forward
  - Match materials-col.material-name with AMF material name, for example
- In-fill, raft, and support material selection is already part of the white paper ("material-use")

Paid Printing

- Is what we have in PWG 5100.16: IPP Transaction-Based Printing Extensions sufficient?
  - http://ftp.pwg.org/pub/pwg/candidates/cs-ipptrans10-20131108-5100.16.pdf

Next Steps

- Continue with 3D Printing BOFs, or do we feel that we are ready to work on a spec?
- Are there other people, companies, or organizations that we should invite to participate?