The Printer Working Group

How Standards Can Help Foster Growth in the 3D Printing Environment

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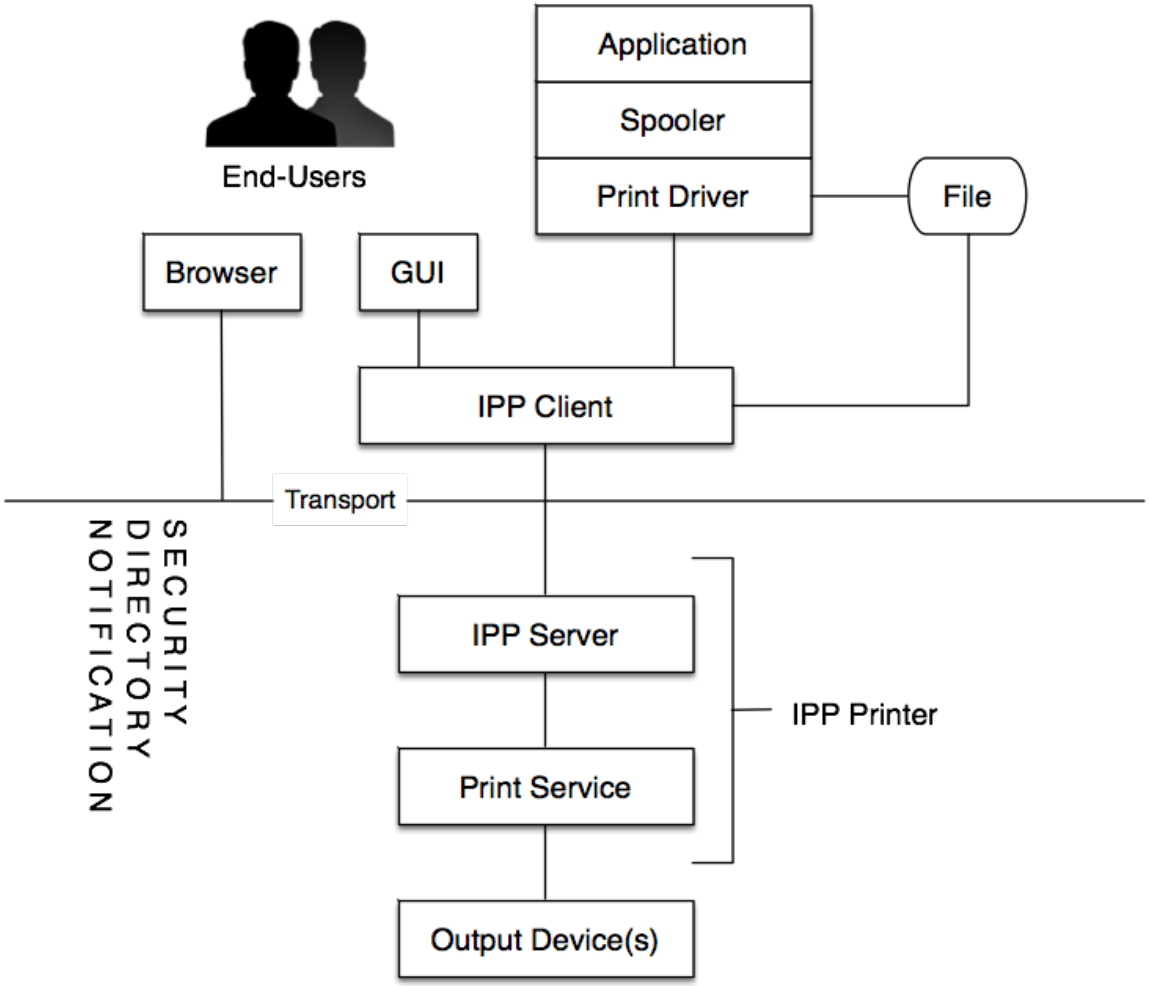
PWG Background

- The PWG is a group of 29 printer manufacturers, operating system providers, print service and management application developers.
- With origins in 1991 as the Network Printing Alliance, the PWG has become a part of and/or worked with general standards organizations to generate standards that communicate User Intent to networked Printers and communicate Printer Capabilities and Status to Users:
  - As an IEEE WG to standardize a hardware interface - IEEE-1284
  - As an IETF WG to generate the Printer MIB and the Internet Printing Protocol (IPP) set of standards
  - As an IEEE-ISTO Program, supporting and continuing the work done under IETF
  - With W3C, drafting the initial XHTML-Print and CSS-Print documents
  - With DMTF, generating Printer CIM
  - With Broadband Forum, generating Printer management schema

Internet Printing Protocol

- Secure, extensible network printing protocol
- Rich, well-defined semantics and job processing model
- Bonjour/DNS-SD and LDAP widely supported for discovery
- Used in 98+% of 2D printers sold today

Generalized IPP Model (RFC 2911)



IPP Security Architecture

- TLS (encryption) of data in transit
- Support for authentication and authorization using Kerberos/Active Directory, OAuth, etc.
- Well-defined baseline policies for user, operator, and administrative operations
- Integrates well with existing network access protocols like TNC

IPP Printer Capabilities and State Model

- Supported and loaded ("ready") media/capabilities are reported by the Printer
- State model reports Printer subunits and conditions

IPP Supports Job Tickets

- Intent-based ("I want to print this with US Letter media") instead of hardware/process-based ("Use sheets from tray 3 using media path 4.")
- With 3D Devices, Job Tickets are used to define materials required for a build and the print object to be created from the build

IPP Job Processing

- Printer capabilities provide supported and default values
- Job tickets provide processing intent to Printer for each Job
- Job receipts provide accounting information to Client for each Job
- Job processing state model (pending/pending-held -> processing/processing-stopped -> aborted/canceled/ completed)

IPP Job Receipts

- Provide a receipt of what was printed, the media/ supply usage, etc.

PWG Semantic Model

- Abstract XML model/schema based on IPP
- Use to map between different print systems/Job Tickets
- Web services bindings (WSDL/SOAP)

Github Organization and Repositories

- Semantic Model Repository
  - https://github.com/istopwg/pwg-semantic-model
- IPP Everywhere Self Certification Tools
  - https://github.com/istopwg/ippeveselfcert

IPP 3D Printing Extensions

- Project within IPP workgroup
- First "prototype-ready" draft in review:
  - http://ftp.pwg.org/pub/pwg/ipp/wd/wd-ipp3d10-20160430.pdf
- Representatives from the 3D PDF Consortium, Adobe, Makerbot/Stratasys, and Ultimaker have contributed to the development of this specification.
- Defines a high-level interface to 3D printers (NOT g-code)

IPP 3D Printing Overview

- Extends 2D data model to consumer/non-industrial 3D printing
- Supports direct printing, cloud-based, and print service solutions
- Bonjour/DNS-SD and LDAP discovery mechanisms are defined
- 3MF is the baseline required document format
- PDF 1.7+ with U3D or PRC is recommended

IPP 3D Printer Capabilities and State Model

- Supported and loaded ("ready") materials/capabilities are reported by the Printer
- State model is extended for 3D Printer subunits and conditions
- State Model Exception Conditions for 3D Devices
  - Clogged Extruder
  - Extruder Temperature Out of Range
  - Extruder Head Movement Issues
  - Filament Feed Jam
  - Filament Feed Skip
  - Material Empty
  - Material Adhesion Issues
  - Print Bed Temperature Out of Range
  - Print Bed Not Clear

IPP 3D Job Tickets

- Intent-based ("I want to print this with Blue PLA") instead of hardware/process-based ("Use filament from spool 3.")
- Material specification includes type ("flexible PLA"), color ("blue"), temperature range, and purpose ("shell", "support", etc.)
- Multiple objects can be printed as part of a single job
- Printer/Cloud service is responsible for determining suitable slicing/hardware parameters based on the Job Ticket parameters.

IPP 3D Job Processing

- Access to camera video as well as standard IPP job state
- New printer state values specific to 3D printers

IPP 3D Job Receipts

- Provide a receipt of what was printed, the material usage, etc.
- Possibility to provide audit trail for things like safety in the 3D environment

Cloud-Based 3D Printing

- Uses existing IPP extension (PWG 5100.18)
- Supports slicing and remote view of camera video