The Printer Working Group

Standards for 3D Printing

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About the Printer Working Group

- The PWG is a Program of the IEEE Industry Standard and Technology Organization (ISTO) with members including printer and multi-function device manufacturers, print server developers, operating system providers, print management application developers, and industry experts
- Originally founded as an IETF WG in 1991
- Standards body responsible for SNMP Printer, Finisher, and Job MIBs as well as the Internet Printing Protocol (IPP) and PWG Semantic Model
  - IPP has been in 2D printers since 1999 (20 years), in 98%+ of all 2D printers sold in the world today
- We enjoy an open standards development process, and all specifications are freely available

3D Printing Standards Work

- Web page:
  - https://www.pwg.org/3d
- Initial standards work began with a "Birds of a Feather" session at the August 2014 PWG Face-to-Face meeting
- PWG Candidate Standard 5100.21-2019: "IPP 3D Printing Extensions v1.1" was developed by the IPP workgroup as part of an effort to enable direct and service-based 3D printing
- The IPP workgroup also defined a PWG Semantic Model (XML) schema based on this IPP extension suitable for data exchange and embedding within common 3D file formats such as 3MF and 3D PDF documents so that user intent is preserved regardless of the transport or workflow used.
  - "PWG 3D Print Job Ticket and Associated Capabilities v1.0 (PJT3D)" was published as a best practice document in August 2017

IPP 3D Printing Extensions v1.1

- The 1.1 specification has a focus on FDM/"desktop" printers
  - Extensible model allows us to support other materials and technologies easily
- IPP provides access control, authorization, and authentication over a secure transport
- IPP provides an abstract data model for representing materials, printer sub-units, and state
- IPP provides intent-based Job Tickets and Printer Capabilities - the User specifies *what* they want and the Printer determines *how* to do it
- IPP provides Job Receipts which record accounting information such as the material usage, processing times, and so forth

IPP 3D Printing Extensions v1.1

- For printers with slicing capabilities, IPP 3D requires support for the 3D Manufacturing File Format (3MF) and recommends support for PDF with U3D or PRC 3D content
  - 3D PDF Consortium is looking into adding support for one of the ISO STEP standards to 3D PDF as well
  - AMF was considered for the standard but isn't freely available and most implementations only support a subset
  - ... but IPP *does* support any file format a printer supports
- We don't currently have a required layered (pre-sliced) format
  - Two recommended formats: "Safe" G-Code and 3MF Slice
  - The PWG Safe G-Code Subset "best practice" document (Formal Approval expected in June 2019) defines a "safe" subset of G-Code for FDM printers without slicing capabilities
  - 3MF Slice Extension scales better to different technologies

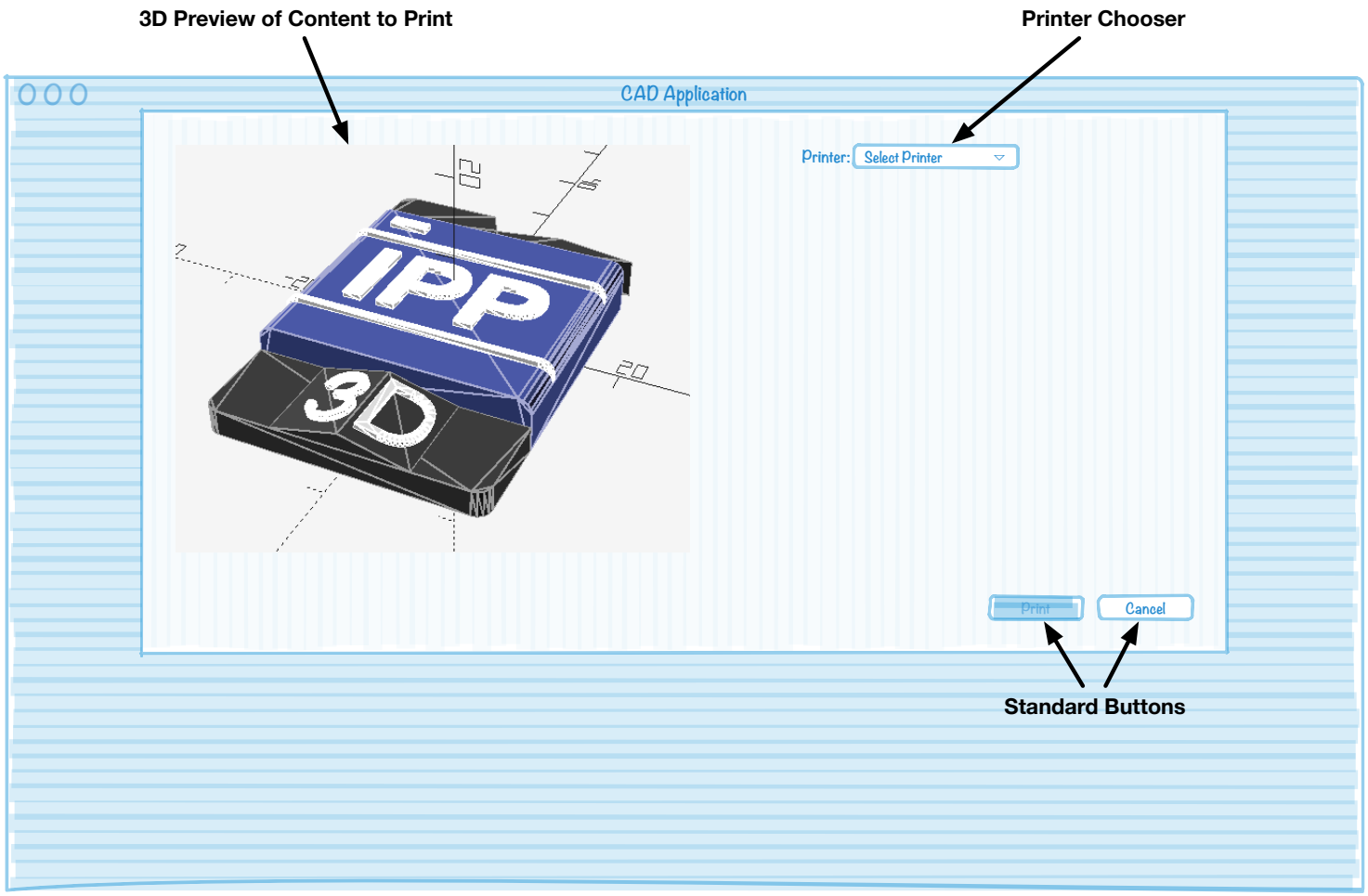
AAA and Security

- IPP supports all of the standard HTTP authentication schemes (Basic, Digest, OAuth, MutualAuth, Negotiate, etc.) plus X.509 certificate validation over TLS
- Commonly used with LDAP-based authorization frameworks (ActiveDirectory, OpenDirectory, etc.)
- IPP 3D requires TLS (1.2 or higher) support

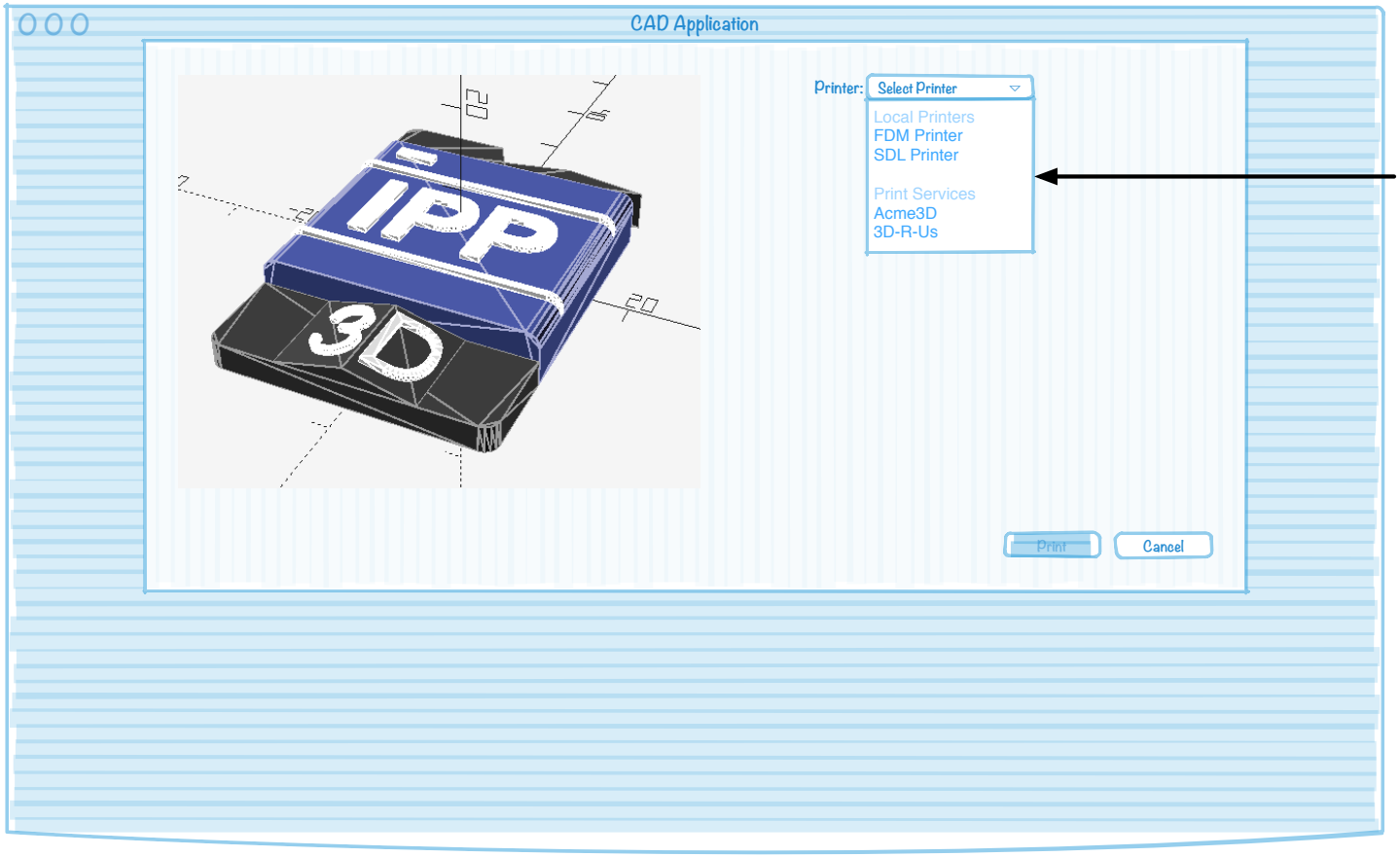
Abstract Data Model

- Every printer is different, so the PWG developed a high-level abstract data model to enable useful monitoring for maintenance, availability/reliability, etc.
- Key information is preserved (classes of sub-units, types of materials, temperatures, levels, etc.) without exposing implementation details that are not needed

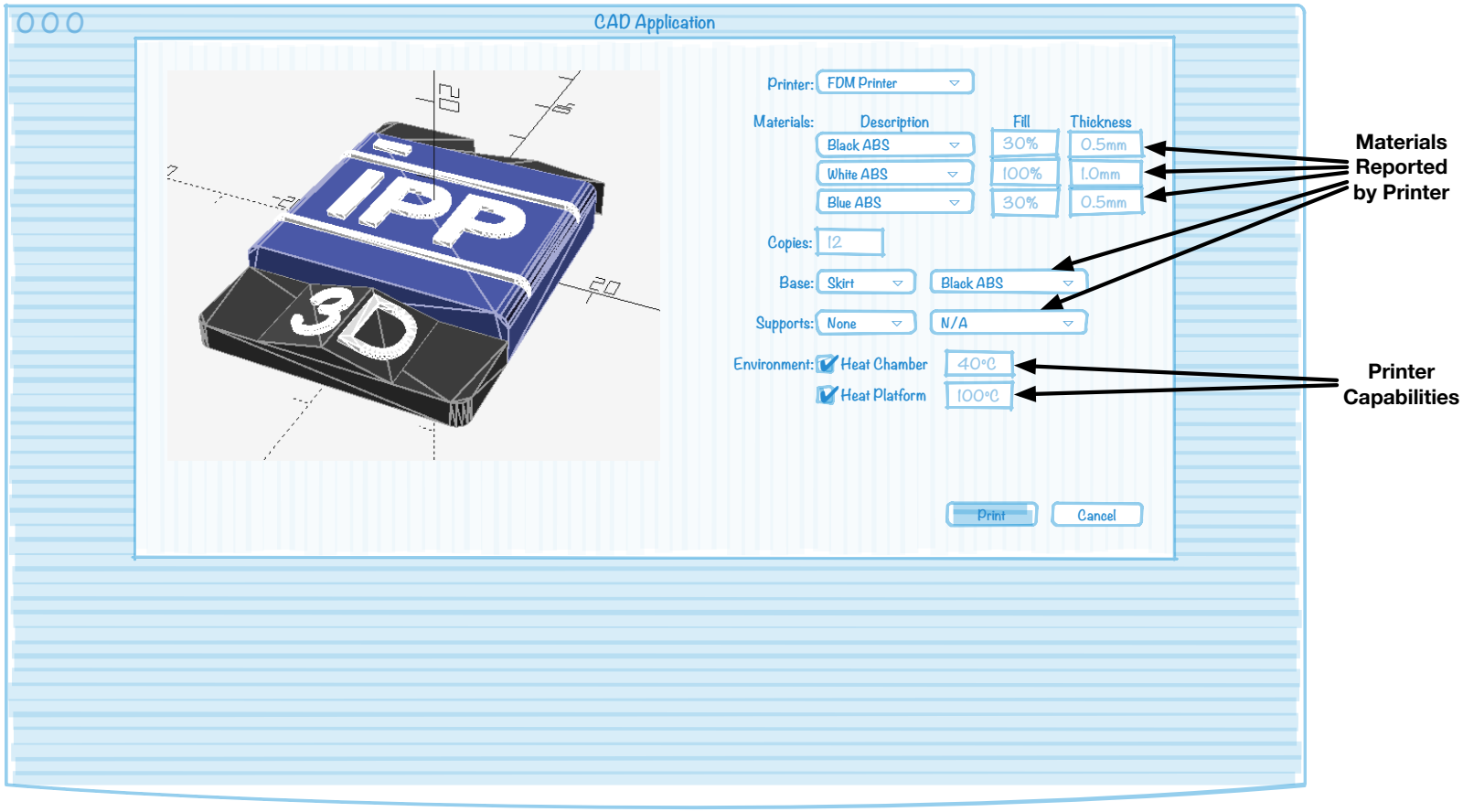
Printer UI Derived from Capabilities



Printer UI Derived from Capabilities



Printer UI Derived from Capabilities



Intent-Based Job Tickets

- IPP assumes that the printer knows how to print something - we don't tell the printer to move the extruder head or prepare a powder bed, we tell it we want an object printed with a certain material and a certain accuracy
- Job Ticket and Capabilities reflect the minimum information needed for the printer to process a job as the user intends
- *What*, not *how*

Job Receipts

- Records the actual Job Ticket values that were used, including how much of each material was used, errors that occurred during processing, and so forth
- Primary usage is for accounting, but also can be used operationally for determining supply orders, maintenance periods, etc.

How to Participate

- We welcome participation from all interested parties
  - Participation is free and does not require PWG membership
- IPP Working Group web page
  - https://www.pwg.org/ipp/index.html
- Subscribe to the IPP mailing list
  - https://www.pwg.org/mailman/listinfo/ipp
- IPP WG holds conference calls on alternate Thursdays from 3:00pm to 4:30pm ET
  - Meetings announced on IPP mailing list