Connectivity & Workflows

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Agenda

1. Introduction
   1. Markets and workflows
   2. Types of users: administrators, operators, end users

2. Printing pipeline
   1. Applications
   2. Operating Systems, Spoolers & Drivers
   3. Data formats
   4. RIPs
   5. Communications
   6. Parsing and rendering
      1. Sleek or PDL
      2. When to start printing: buffering
   7. Layout management
   8. Color management
   9. Halftoning
   10. Print modes: passes, masks, coalescence, undercolor
   11. Pens life

3. Printer management
   1. Front panel
   2. Web
   3. Network management
   4. Printer Utility
   5. Calibrations
   6. Accounting, facilities management
   7. Security: firewall, IPsec, authorization
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Introduction: The GOAL

Ideas & information = BITS

Ink & substrates = ATOMS
Introduction: what kind of ideas?

- **Drawings**
  - Schematics
    - architectural
    - mechanical
    - electronics
  - Renderings
    - 3-D
    - ray-tracing, photorealistic
  - Data representation
    - Office (project planning, business charts)
    - GIS

- **Design**
  - Signage (conventions, retail)
  - Covers
  - Packaging

- **Graphic arts**
  - Electronic art
  - Art reproduction (museums)

- **Photography**
  - Artistic
  - Satellite

- **CAD tools**
  - AutoCAD, ESRI
  - Mentor
  - OrCAD
  - MS-Project, Powerpoint
  - GoogleMaps
  - In-design
  - Illustrator
  - Photoshop
Introduction: segments

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- **TECHNICAL**

- **CREATIVES**

- **PSP (Print Service Providers)**
Introduction: types of users and roles

- End user
- Administrator
- Operator
- Maintainer
- Service
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Applications

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Internal application working formats

CAPTURE
Printing formats

• Exchange formats (TIFF, PS, PDF, XPS, HPGL/2, SVG) vs. printer-specific formats (PCL, PCL3GUI)

• low level raster (TIFF, PCL3GUI) vs. high-level Page Description Languages (HPGL/2, PS, PDF, XPS)
  - Expressiveness of a PDL may be a plus or a minus

• Job intent meta-information (PJL, JDF, JobTicket) vs. pure content (TIFF, HPGL/2)

• Streamable (HPGL/2, PS) vs non-streamable (TIFF, PDF)

• Food for thought:
  - Are HP-proprietary formats appropriate? why?
  - Are application working formats appropriate? why?
  - Is a richer PDL always better? Is raster always better?
Applications: print support

- Can export exchange file formats
  - HPGL/2
  - PS
  - PDF
  - TIFF
- Can use the OS printing framework
  - Windows
  - MacOS
  - Linux
- Can load plug-ins
- Provide their own printing driver framework
- Do not support printing

- Adobe apps
- Caldera (CAD)
- Graphics/photo apps
- Photoshop
- AutoCAD ADI
Applications

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Exchange format
OS printing framework
Application plug-in
Application printing driver

Application-independent
Printer-understandable
May contain job settings
OS drivers and printing frameworks

Application → File generation → Content transformation filter → Spool file

Content transformation filter

Spool format: EMF, PDF, XPS

GUI: Settings & config

I/O manager
Data formats

• Raster
  − Contone
    • RGB
    • CMYK
    • n-channel
      ❖ color depth
      ❖ gamut
  − Named colors
    • Pantone
    • Spot colors
  − Halftone

• Vectorial (high-level Page Description Languages)
  − Lines, polgons
  − fonts and font engines
  − Advanced primitives: clip-to-path, gradients, transparencies (alpha-blending), non-linear transformations

• “Stream-ability” vs. print-while-receiving
Raster Image Processors (RIPs)

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Raster Image Processors (RIPs)

Added value

- High-level PDL processing (PS, PDF, TIFF, XPS)
- Layout, imposition, tiling
- Color management
- Media support (ink limiting, gamma linearization, masking)
- Image enhancements
- Document management
- Printer clustering
- Screening, halftoning
- Calibrations and printer management
- Security, DRM
Communications

• Direct connect: USB, Firewire

• Network:
  - Link layer: 10/100/1000 BaseT
  - Network/transport layer: Novell, Appletalk, TCP/IP, IPv6
    • Security: IPsec, SSL/TLS, X.509 certificates
  - Application layer: raw9100, LPR, FTP, web

• Activities:
  - Device Discovery (plug&play)
  - Printer Configuration
  - Host configuration: driver installation, I/O manager, queues
  - Network presence and service discovery: autoIP, link-local address, mDNS, DDNS, WINS, WS-Discovery

• Throughput (example: 60", 60ips, 1200dpi, RGB)

• Compression
  - Lossy vs. lossless
  - Spatial frequency: 2-D FFT
  - Nyquist & aliasing: subsampling, low-pass filtering and edge enhancement
Sending a printable file with no RIPs

- **copy /b file LPT:** (Windows)
  - no job settings
  - only to installed printers

- **FTP: put file**
  - no job settings
  - only over network, any reachable printer

- **Embedded web server**
  - job settings
  - preview available
  - both network and direct connect (!!)
  - browsers are quite slow uploading huge files (not their usual job)

- **Hot folders**
  - predefined job settings per folder (from web UI)
  - Using “USB mass storage device class” or FTP over network
  - fast and intuitive
Parsing and rendering

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Sleek or PDL?

- **Sleek**
  - Print while receiving, no storage
  - Low computation: cheap CPU, no disk
  - Huge amount of raster data, in-sync with printing: expensive I/O
  - Most work on host: high CPU usage, no available hw assist
  - Usually proprietary format that requires an HP proprietary driver or library

- **High-level PDL**
  - Process while/after receiving, print while/after rendering
  - High computation: expensive CPU, disk, RAM
  - Relatively low amount of data, off-sync with printing: cheap I/O
  - Most work on printer: host free, possible specialized hw assist
  - Enables sophisticated operations
  - Enables image enhancements (scaling, edge enhancement, color improvements)
  - Independent of a proprietary HP driver/library
When to start printing

• Print-while receiving: start printing as first pass data is available
  − Very risky: any I/O delay translates into IQ defect

• Print after processing: very slow, huge storage needed

• Optimized: buffering is used to measure average I/O rate and estimate a safe time to start
Layout management

- Nesting: try to group jobs to optimally use paper printing as many as possible side-by-side
- Imposition: newspapers, covers, magazines
- Auto-rotation: rotate a job 90 degrees to better use the paper
- Mirror: to print on backlit media
- Collate: on a multipage job, do copies by page or by job
Color management

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Color management

• Additive (light) vs. subtractive (ink) color
• Human color perception: rods & cones, CIE XYZ (http://gusgsm.com/estandares_cie)

• Gamut
Color management

- Device dependent color
  - RGB
    - sRGB
    - Adobe RGB
  - CMYK, n-contone
    - Press emulation: SWOP, Euroscale, Toyo, ISO12642
- Device independent color
  - CIE L*a*b*
  - Named colors: Pantone, spot colors
- ICC Profiles: colorimeters & spectrophotometers
  - Colorimetric
  - Perceptual
Color separation

• From logical color (RGB, CMYK, CIELAB) to physical inks (CMYK, KCcMmY, CMYKkg, CMYKRGB, hexachrome, etc)
  – Interpolated LUTs

• Adding physical interactions considerations:
  – ink limiting
  – coalescence
  – smearing (color-into-color)
  – Gamma correction (linearization)
    • densitometer
    • Closed-loop color
Halftoning

- From 8-bits or 16-bits per pixel to 1/2/4 ink levels
- Methods
  - screening (AM)
  - clustering (AM)
  - pattern dithering
  - stochastic dithering (blue noise, FM)
  - error diffusion
Finally... writing !!

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Print modes

• Coalescence
• Resolution = Addressability + dot size (drop volume)
  - depletion
  - edge enhancement
• Passes
• Masks
• Error hiding
• Undercolor
• Paper advance
Pens and cartridges life

• Servicing
  - Spitting
  - Wiping
  - Priming
  - Capping

• Estimating remaining ink
  - Drop counting
  - Measuring: inductive, capacitive, bag&spring
  - Job reassurance: ink coverage estimation for a job

• Drop detection
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Front panel

- LCD, buttons, LEDs, beeper
- Menus:
  - printer configuration
  - default job settings
  - operator activities (load media, cartridge/pen replacement, calibrate)
  - service activities (self-diagnostics, special startup modes, calibrate)
- Status
- Help and guidance (text and/or animations)
- Error information
- Localized in 12 languages, including Asiatics, Cyrillic, Greek
Embedded Web Server

- For complex activities, this is the printer UI, since the front panel is very limited (small display, no text entry, no mouse)
- Most value-added applications executable inside the printer are accessible through the EWS as the UI
- It is a full application server
- Full status and printer configuration
- Image Quality wizard
- Pantone swatchbook
- Job submittal
- e-mail notifications (administrator/operator alerts)
- Security (certificates, administrator password, IPsec management)
- Firmware upgrade
Network management

- SNMP-enabled for remote management
  - Compatible with standard tools like HP OpenView and IBM Tivoli
  - Standard Printer MIB, Host Resources MIB, Networking MIB (a.k.a. “MIB II”)
  - Proprietary HP MIB

- DHCP, DDNS, mDNS, WINS, LLMNR

- Fleet management: WebJetAdmin
  - Status and configuration
  - Firmware upgrade

- Web Services
  - MS Web Services for Devices
  - Proprietary API
Printer Utility

- Host application
- Status, configuration
- End user alerts
- System assessment and upgrade
- Color calibrations
  - Launch
  - Get ICC profile and install on host OS
- New media definition and management
3rd party support

• External software vendors that make applications for HP large-format printers
  − For vertical markets: “plan rooms”, RIPs, proofing, newspapers
  − Added value: better print quality, screening emulation, new media or special inks support, tiling

• They can get:
  − SDK:
    • raster transformation library
    • status
    • job manager control
    • calibration control
    • sensor data gathering
    • accounting data
  − Documentation: SNMP MIBs
  − Web Services WSDL
  − Certification Program: logo that certifies a certain application correctly interacts with a certain printer for a well-defined level of functionality
Calibrations

- Some device parameters require calibration by user
  - Linearization: new media, new pen, new ink, new climatic condition (!!)
  - ICC profile: new media, new ink, new host (!!)
  - Line accuracy: new media, periodically
  - Pen alignment: new pen, thicker/thinner media

- These processes are used by operator or maintainer

- They can be launched from:
  - front panel
  - web server
  - printer utility
  - automatically (on pen replacement)
Accounting and facilities management

- Accounting: total usage of supplies in a certain machine; used by
  - renting/leasing/services companies
  - maintenance and supplies reordering tools/services
  - HP service
  - HP marketing (to know about actual usage data)

- Facilities management: detailed log of jobs printed, with supplies usage per job, as well as username or department name; used by
  - Enterprise: IT or facilities departments to charge per use
  - SMB: expense control, cost-per-page mgmt

- Data provided as
  - HTML in web server
  - XML via HTTP-get or SOAP web service
  - Excel file
Security

- A networked printer is a networked computer... **VULNERABLE !!**
- An embedded device can have its firmware upgraded from time to time, certainly not frequent security patches
- The printer has many different operation modes with different requirements in terms of network access and kinds of applications running

- Managed firewall: depending on configured services and on execution mode, it protects all ports except those actively enabled
- X.509 certificates: Via the EWS and via web services APIs it is possible to install and manage the certificates inside the printer
- SSL/TLS: the EWS, web services and SNMP can be protected with SSL
- IPsec: authenticated and encrypted connections can be configured for each service, for port ranges and for peer address or subnet, supporting MD5 or SHA1 with 3DES or AES-128, with auto key negotiation (IKE)