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White Paper



The Printer Working Group

CWMP Data Models for Printers and MFDs (CWMPMFD)

Status: White Paper

Abstract: The purpose of this white paper is to propose input for future Broadband Forum Technical Reports that would define new data models for printers, multifunction devices (MFDs), other imaging devices that are managed as customer premises equipment (CPE) devices:

- (a) Guidance for remote management of printers and MFDs via Broadband Forum CPE WAN Management Protocol (CWMP) [TR-069];
- (b) Guidance for CWMP Proxy implementations that communicate with printers and MFDs using their native IPP, SNMP, and/or web services, e.g., PWG Print Service;
- (c) Data model for PrintService, with an XML schema binding, that follows the BBF Data Model Template for TR-069-Enabled-Devices [TR-106] and is composed of the machine-translated existing objects, element groups, and elements defined in the PWG Semantic Model v2.0 XML schema; and
- (d) Data models for Scan, Fax, MFD (i.e., System) and various other PWG SM services, that follow the BBF Data Model Template for TR-069-Enabled-Devices [TR-106] and are each composed of the machine-translated existing objects, element groups, and elements defined in the PWG Semantic Model v2.0 XML schema.

This document is a PWG White Paper. For a definition of a "PWG White Paper", see:

<ftp://ftp.pwg.org/pub/pwg/general/pwg-process30.pdf>

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53 systems supporting them work together better. All references to the PWG in this
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56 standards that define print related protocols, interfaces, procedures and conventions.
57 Printer manufacturers and vendors of printer related software will benefit from the
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59 In general, a PWG standard is a specification that is stable, well understood, and is
60 technically competent, has multiple, independent and interoperable implementations with
61 substantial operational experience, and enjoys significant public support.

62 For additional information regarding the Printer Working Group visit:

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133 **1. Introduction**

134 This document focuses on the evolution of the Managed Print Services (MPS) industry
135 and the broadband Telecommunications (Telecom) industry and has primary goals of
136 supporting automatic, remote, secure configuration of newly installed printers and then
137 securely managing them throughout their lifecycle.

138 Since the mid-1990s, high-quality digital printing technologies have become widespread.
139 This has led to the convergence of traditional copiers and printers and the subsequent
140 development of a new class of multifunction devices (MFDs). Older stand-alone office
141 equipment typically performed a single copy, print, scan, or fax function. Newer MFDs
142 have evolved to support all of these basic functions and also often include email, resource
143 management, document transform, document storage, and other imaging services.

144 In recent years, managed print service (MPS) providers have offered proactive supplies
145 and maintenance service contracts to business, government, and university customers.
146 The key limitation for MPS market growth has been the lack of a single, comprehensive
147 monitoring and management interface across the current generation of MFDs.

148 Currently, device and service information about printers is typically available via SNMP
149 using IETF MIB-II [RFC1213], IETF Host Resources MIB v2 [RFC2790], PWG Imaging
150 System State and Counter MIB v2 [PWG5106.3], PWG Job Monitoring MIB [RFC2707],
151 IETF Printer MIB v2 [RFC3805], IETF Finisher MIB [RFC3806], PWG Printer Port Monitor
152 MIB [PWG5107.1], and PWG Imaging System Power MIB [PWG5106.3].

153 On the other hand, service and job information about printers is typically available via
154 IPP/1.1 [RFC2911] and often via the newer IPP versions 2.0, 2.1, and 2.2 [PWG5100.12].

155 Currently information about other imaging services and MFDs overall is not available via
156 open standard interfaces (i.e., the suite of PWG Semantic Model abstract services and
157 WSDL/SOAP bindings).

158 Meanwhile, the Telecommunications (hereafter, Telecom) service providers have also
159 changed dramatically. High-speed Internet and other data communications customer
160 endpoints have become widespread, affordable, and reliable. Older single-function
161 telecom customer premise equipment [CPE] such as land line telephones, set-top boxes
162 (STBs), and mobile phones have converged and given rise to multifunction high-speed
163 media offerings.

164 In the past, telecom infrastructure devices such as routers, bridges, cable modems, and
165 DSL modems were monitored and managed via SNMP and TELNET/SSH. More recently,
166 the telecom industry has migrated to the use of Broadband Forum CPE WAN
167 Management Protocol (CWMP) [TR-069]. And the current generation of CPE devices are
168 typically also managed using CWMP.

169 Telecom providers have now joined MPS providers as suppliers of printers and MFDs
170 under service contracts in homes and businesses. Note that current telecom CPE device
171 have more complex life-cycles than current printers and MFDs. A telecom CPE device is
172 typically installed with entirely automatic initial configuration and is subsequently
173 frequently updated with new firmware and new services, again via automatic
174 configuration.
175

176 **2. Terminology**

177 **2.1 Conformance Terminology**

178 Capitalized terms, such as MUST, MUST NOT, REQUIRED, SHOULD, SHOULD NOT,
179 MAY, and OPTIONAL, have special meaning relating to conformance as defined in RFC
180 2119 [RFC2119].

181 **2.2 Printing Terminology**

182 Normative definitions and semantics of printing terms are imported from IETF Printer MIB
183 v2 [RFC3805], IETF Finisher MIB [RFC3806], and IETF IPP/1.1 [RFC2911].

184 This document also defines the following protocol roles in order to specify unambiguous
185 conformance requirements:

186 IPP Client - Initiator of outgoing IPP session requests and sender of outgoing IPP
187 operation requests (HTTP/1.0 Client [RFC1957] / HTTP/1.1 Client [RFC2616]).

188 IPP Printer - Listener for incoming IPP session requests and receiver of incoming IPP
189 operation requests (HTTP/1.0 Server [RFC1957] / HTTP/1.1 Server [RFC2616]).

190 SNMP MIB Agent: Listener for incoming SNMP Get and Set management requests and
191 sender of optional outgoing SNMP notifications for a Printer or MFD (i.e., an SNMP
192 Agent).

193
194 SNMP MIB Client: Initiator of outgoing SNMP Get and Set management requests and
195 receiver of optional incoming SNMP notifications for a Printer or MFD (i.e., an SNMP
196 Manager).

197 **2.3 Telecommunications Terminology**

198 Normative definitions and semantics of telecommunications management terms are
199 imported from Broadband Forum CPE WAN Management Protocol [TR-069], including the
200 following:

201
202 Applied – A change to the Customer Premise Equipment (CPE) configuration has been
203 applied when the CPE has stopped using the previous configuration and begun using the
204 new Subunits.

205 Auto-Configuration Server (ACS) – This is a component in the broadband network
206 responsible for auto-configuration of the Customer Premise Equipment (CPE) for
207 advanced services.

- 208 Committed – A change to the Customer Premise Equipment (CPE) configuration has
209 been committed when the change has been fully validated, the new configuration appears
210 in the configuration data model for subsequent Auto-Configuration Server (ACS)
211 operations to act on, and the change will definitely be applied in the future, as required by
212 the protocol specification.
- 213 Customer Premises Equipment (CPE) – Refers to any TR-069-compliant device and
214 therefore covers both Internet Gateway Devices (IGDs) and LAN-side end devices.
- 215 Data Model – A hierarchical set of parameters that define the managed objects accessible
216 via [TR-069] for a particular device or service.
- 217 Deployment Unit (DU) – An entity that can be individually deployed on the Execution
218 Environment. A Deployment Unit can consist of functional Execution Units and/or
219 configuration files and/or other resources.
- 220 Device – Used interchangeably with CPE in [TR-069].
- 221 Execution Environment (EE) – A software platform that enables the dynamic loading and
222 unloading of Software Modules. Typical examples include Linux, OSGi, .NET, and Java
223 ME. Some Execution Environments enable the sharing of resources amongst modules.
- 224 Execution Unit (EU) – A functional entity that, once started, initiates processes to perform
225 tasks or provide services, until it is stopped. Execution Units are deployed by Deployment
226 Units. The following list of concepts could be considered Execution Units: services,
227 scripts, software components, libraries, etc.
- 228 Internet Gateway Device (IGD) – A Customer Premise Equipment (CPE) device, typically
229 a broadband router, that acts as a gateway between the WAN and the LAN.
- 230 Managed Print Service (MPS) – A service model that adds value to MFDs and printers by
231 combining provisioning, maintenance, and supplies into Service Level Agreements
232 (SLAs).
- 233 Parameter – A name-value pair representing a manageable CPE parameter made
234 accessible to an ACS for reading and/or writing.
- 235 Residential Gateway (RGW) – A gateway between the end user premise and the
236 broadband service network (i.e., the Telecom network, not the Internet) that is introduced
237 for architectural clarity in [TR-196].
- 238 Set Top Box (STB) – A television set top box that supports multimedia and Internet
239 access by the end user.
- 240 Session – A contiguous sequence of CWMP transactions between a Customer Premise
241 Equipment (CPE) and an Auto-Configuration Server (ACS). Note that a Session may
242 span multiple TCP connections.

243 Software Module – The common term for all software (except firmware) that will be
244 installed on an Execution Environment, including the concepts of Deployment Units and
245 Execution Units.

246 Transaction – A message exchange between a Customer Premise Equipment (CPE) and
247 an Auto-Configuration Server (ACS) consisting of a single request followed by a single
248 response, initiated either by the CPE or ACS.
249

250 **3. Requirements**

251 **3.1 Rationale for Printer and MFD Management via CWMP**

252 **3.1.1 Rationale from IETF and PWG Perspective**

253 IETF and PWG standards for the printing industry define:

- 254 (a) A rationale for an abstract model of printing (to support alternate encodings and
255 protocols) in section 3 of the IETF IPP Rationale [RFC2568];
- 256 (b) A set of design goals for status monitoring in a printing protocol in section 3.1.3
257 'Viewing the status and capabilities of a printer' (for End User), section 3.2.1
258 'Alerting' (for Operator), and section 3.3 'Administrator' (the bullet requirement to
259 'administrate billing or other charge-back mechanisms') of the IETF IPP Design
260 Goals [RFC2567];
- 261 (c) An abstract model of a Print Service (i.e., ISO DPA Logical Printer) and a Print
262 Device (i.e., ISO DPA Physical Printer) in section 2.1 of IETF IPP/1.1 [RFC2911];
- 263 (d) An abstract model of a Print Device and contained Subunits in section 2.2 of the
264 IETF Printer MIB v2 [RFC3805];
- 265 (e) An abstract model of Finishing Subunits integrated into the Printer Model (from
266 [RFC3805]) in section 3 of the IETF Finisher MIB [RFC3806];
- 267 (f) A set of Finishing Subunit types in the 'FinDeviceTypeTC' textual convention in
268 IANA Finisher MIB [IANAFIN], originally published in section 7 of the IETF Finisher
269 MIB [RFC3806]; and
- 270 (g) An abstract model of a Multifunction Device in section 2 of the PWG MFD Model
271 and Common Semantics [PWG5108.01].

272 When deploying printers and MFDs in home and office CPE environments based on
273 telecom service agreements, initial configuration via SNMP and Embedded Web Server is
274 neither feasible nor scalable.

275 Therefore CWMP printer and MFD data models SHOULD:

- 276 (a) Standardize native CWMP support for secure operations on printers and MFDs;
- 277 (b) Standardize capabilities to manage, provision, and service these CWMP-based
278 printers and MFDs;
- 279 (c) Encourage adoption of modern IPP-based printing infrastructures;

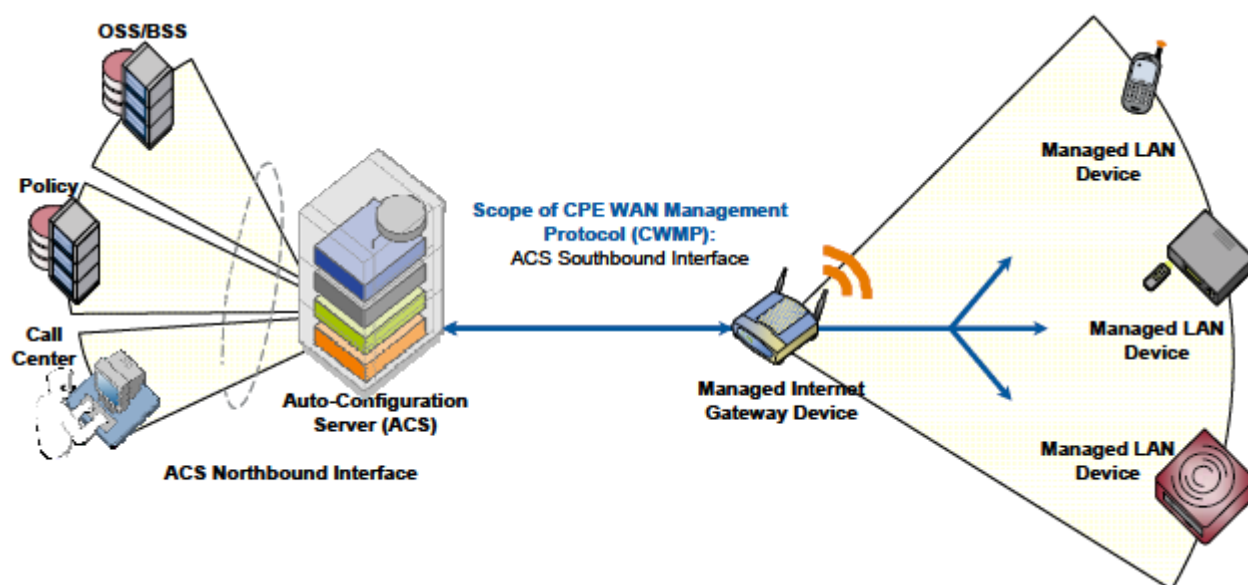
280 (d) Encourage adoption of modern PWG Semantic Model-based MFD infrastructures.

281 3.1.2 Rationale from Broadband Forum Perspective

282 The Broadband Forum CPE WAN Management Protocol (CWMP) standard [TR-069]
 283 defines a set of standard interfaces between the Auto-Configuration Server (ACS) of a
 284 service provider and all customer premise equipment (CPE) devices in a customer's
 285 network that supports the CWMP device data model.

286 Figure 1 below is excerpted from section 1.2 of Broadband Forum CWMP [TR-069] and
 287 depicts the scope of CWMP in an end-to-end WAN network architecture.

288



289

290 **Figure 1 – Broadband Forum CWMP End-to-End Architecture**

291 Implementation of CWMP in MFDs would enable a service provider to offer the following
 292 advantages throughout the lifecycle of an MFD product:

293 (a) Ease of Deployment: Web-based remote selection, activation, and control of pay-
 294 per-use services (e.g. print, copy, scan, fax);

295 (b) Touchless Installation: Automatic discovery, secure configuration, and policy-
 296 based setup of MFDs, printers, and their imaging services that is scalable to
 297 support many thousands of users according to each user's/group's profile and
 298 service contract and the customer's business policies (e.g., access control and
 299 monetization of print, fax, scan, copy and other services based on time, volume,
 300 user ID, features, payment models, etc.). This is similar to the way mobile phones
 301 can be remotely identified, configured, and setup on a broadband network today;

302 (c) Remote Device Management: Provides automatic and secure software/firmware
303 downloads, upgrades, patches, and new value-add services to MFDs, printers,
304 and other imaging devices – provides automatic performance/status monitoring of
305 imaging devices and services; and

306 (d) Remote Diagnostics/Troubleshooting: Provides improved problem resolution
307 capability – eliminates unnecessary and costly device replacement – enhances
308 customer support process.

309 Broadband Forum CWMP standards for the Telecom industry include:

310 a) A broadband management architecture for CPE devices in CWMP [TR-069];

311 b) A data model template for all devices that support CWMP in [TR106];

312 c) A common device data model in [TR-181];

313 d) An Internet Gateway Device (IGD) data model in [TR-098]; and

314 e) A series of device-specific CWMP data models based on [TR-106] for DSLHome™
315 for VoIP [TR-104], Set Top Boxes [TR-135], Storage Service enabled devices [TR-
316 140], and Femto access points [TR-196].

317 There is no currently defined standard TR-069 data model defined for MFDs.

318 By collaborating to propose this MFD data model, the PWG is leading the way for the
319 inclusion of MFDs and printers as part of the managed services offered by Telecom
320 operators by leveraging the PWG Semantic Model [PWG5108.1]. In addition, the PWG is
321 supporting the use of CWMP for MFDs and printers by MPS providers, who will also gain
322 the advantage of managing any TR-069 enabled device – be it a storage device,
323 communications device, or a computing device – this CWMP support would allow MPS
324 providers to evolve into Managed Service Providers (MSPs), in order to compete more
325 effectively with traditional IT and Telecom service providers.

326

327 **3.2 Use Cases**

328 The use cases below are written from the perspective of the End User or local Admin of
329 the MFD or printer being managed as a CPE device.

330 **3.2.1 MFDs managed by Telecom Providers**

331 Customers in home and enterprise environments can use MFDs/Printers that are
332 deployed and maintained by Telecom providers. When the PWG Semantic Model is
333 supported in the proposed Broadband Forum data model for MFDs/Printers, Telecom
334 providers will be able to add these imaging device products into their value added
335 services as part of their managed services portfolios. A user could purchase or lease a
336 TR-069 enabled MDF/Printer, plug it into their network, and have the device automatically
337 securely configured by the Telecom provider's ACS (management server). Based on
338 which services the user has already subscribed to, the device will be appropriately
339 provisioned. Telecom providers could negotiate marketing and support contracts with
340 printer manufacturers for technical support, field service, and toner/supplies replenishment
341 – this would create a whole new revenue stream through a different channel for the printer
342 manufacturers.

343 **3.2.2 MFDs managed by MPS Providers**

344 Customers in enterprise environments can use MFDs/Printers that have been pre-
345 configured and shipped with the domain address of the ACS (management server) used
346 by the MPS provider. When the MFD or Printer is plugged into the enterprise network, the
347 device will automatically contact the ACS, using its pre-configured credentials. Based on
348 the services that have been purchased by the customer, the ACS will automatically
349 securely configure the device (including any firmware updates if necessary). The device
350 will then be under the control of the MPS provider, who can maintain the SLAs, perform
351 toner/supplies replenishment, schedule service calls, and perform metering for control of
352 service levels as well as billing. Through the lifecycle of the product or the service
353 contract, the device will be managed remotely by the MPS provider. If the customer fails
354 to pay or does not renew the service contract, then the device and its services can be
355 disabled remotely by the MPS provider.

356 **3.2.3 MFDs managed by Enterprise IT Staff**

357 Enterprise communications infrastructure devices – routers, bridges, VoIP switches, video
358 telephony servers, etc. – are already typically managed using Broadband Forum CWMP
359 [TR-069]. By adding CWMP clients to MFDs/Printers, manufacturers can ship devices
360 that can all be managed from a single ACS. When devices are physically moved between
361 departments or policies are deployed for usage of these devices – e.g., able to print only
362 black/white but not color or restrictions of usage by page count – or certain departments
363 require stronger security than others, this will necessitate remote configuration and
364 provisioning of these devices. Once a set of policies are created, configuration of these

365 MFD/Printer devices will become automatic instead of based on extensive manual work
 366 for IT network operators. This would save time, improve enterprise security and ensure
 367 adherence to policy.

368 3.2.4 Print Kiosks managed by Telecom Providers



369

370 **Figure 2 – Print Kiosks and Secure Cloud Print Service**

371 In the Cloud Print use cases below, the mobile phones and print kiosks are managed by
 372 Telecom providers using CWMP. The mobile phones are managed via Telecom cellular
 373 networks, while the print kiosks are managed via Telecom broadband networks. The print
 374 kiosks are monitored for status, provisioned with new services, and remote diagnostics
 375 are all performed by Telecom providers using CWMP.

376 3.2.4.1 Cloud Print via IPP Everywhere

377 Mobile phone users can access any bundled or 3rd party application (Email, Dropbox,
 378 Photoapp, etc.) that shares their desired document (MS Word, PDF, JPEG, etc.) and
 379 press the Print button. Using geolocation or other means (default device, last used
 380 device, etc.) a list of available Print Kiosks from their Telecom's secure Cloud Print
 381 Service is displayed to the user, who then chooses a "nearby" location (same city,
 382 neighborhood, building, etc.). The user's print client submits the selected document via
 383 PWG IPP Everywhere to their Telecom's secure Cloud Print Service specifying the target
 384 Print Kiosk device.

385 3.2.4.2 Cloud Print via Pull Print

386 Mobile phone users can access any bundled or 3rd party application (Email, Dropbox,
 387 Photoapp, etc.) that shares their desired document (MS Word, PDF, JPEG, etc.) and
 388 press the Print button. The user chooses delayed printing and the user's client submits

389 the selected document via PWG IPP Everywhere to their Telecom’s secure Cloud Print
390 Service specifying delayed printing. The user receives a secure job identifier and
391 associated PIN via email, instant messaging, or in-band from their application. At a later
392 time, the user queries for a list of available Print Kiosks from their Telecom’s secure Cloud
393 Print Service and then chooses a “nearby” location (same city, neighborhood, building,
394 etc.). The user walks up to their chosen Print Kiosk and enters their job identifier and
395 secure PIN information. The Print Kiosk displays the price for the print job which the user
396 accepts (adding to their monthly bill). The user’s job is securely pulled from their
397 Telecom’s secure Cloud Print Service via PWG IPP Everywhere and is printed with the
398 requested processing options.

399 **3.3 Deployment Scenarios**

400
401 Because the architecture of the Broadband Forum CWMP [TR-069] is highly scalable and
402 is designed to provide secure remote services in a firewall-friendly manner, several
403 deployment scenarios can be envisioned. No special ports need to be opened up in
404 corporate firewalls, nor is reverse VPN tunneling required for service management – both
405 of which are nightmares for IT security staff.

406
407 An ACS could be deployed as a service in a public cloud, or in a private cloud for an
408 enterprise network, or as a private self- deployment by IT staff. Telecom providers could
409 manage printers in homes, enterprises, and government agencies. MPS providers could
410 manage multiple enterprises (each of which might have multiple physical sites). Printer
411 manufacturers could manage printers in SOHO networks, production printing facilities, or
412 graphic arts companies. Corporate IT staff could deploy CWMP on an in-house server
413 and then manage devices within their Intranets.

414 **3.4 Out of Scope**

415 The CWMP printer and MFD data models must not:

- 416 (1) Define any new content outside the PWG Semantic Model XML schema;
- 417 (2) Define any semantics for workflow applications;
- 418 (3) Define any semantics for document repositories; and
- 419 (4) Define any application-specific semantics for MFD monitoring using CWMP.

420 **3.5 Design Requirements**

421 The CWMP printer and MFD data models should:

- 422 (1) Be based on the PWG Semantic Model XML schema definitions;

- 423 (2) Include all content from the PWG Semantic Model XML schema when possible,
424 e.g., within the limitations of the BBF data model language;
- 425 (3) Follow the naming conventions of the PWG Semantic Model XML schema when
426 possible, e.g., within the limitations of BBF data model parameter object and
427 parameter names and name lengths; and
- 428 (4) Preserve the access control semantics of the PWG Semantic Model XML schema,
429 e.g., PrintServiceStatus abstract elements are read-only.
430

431 **4. CWMP Data Models**

432 This section proposes an outline approach for Broadband Forum [TR-106] data models for
433 Printers, MFDs, and other Imaging Devices that are technically equivalent to the PWG
434 Semantic Model [PWG5108.01]. The top-level PrintService object, named according to
435 the [TR-106] data model conventions, contains the PWG PrintService object.

436 **4.1 Technical Approach**

437 **4.1.1 XML Format of BBF CWMP and PWG SM Models**

438 Each Broadband Forum CWMP data model is written as a single *XML document instance*
439 (.xml) using data model structural elements (model, object, parameter, etc.) and a small
440 closed set of datatypes that are all pre-defined in a separate external CWMP *XML*
441 *document schema* (.xsd) which does NOT allow complex datatypes (choices, unions,
442 sequences, etc.) to be used in parameter definitions (i.e., elements). Instead such
443 complex datatypes can be translated as: (a) string; (b) list (comma-separated list of
444 strings), or (c) sub-objects (sequence of parameters).

445 The PWG Semantic Model, on the other hand, is written as a set of *XML document*
446 *schema* (.xsd) that each define elements using native XML datatypes (as opposed to the
447 fixed BBF subset) and as well as PWG complex datatypes (e.g., element groups, choices,
448 unions, etc.). Therefore, the existing element dictionary defined in PwgCommon.xsd can't
449 simply be converted to a similar BBF data model (e.g., in sequence clauses), since only a
450 parameter statement can be contained in a BBF object. BBF data models do allow both
451 object reference and parameter reference imports – this is being explored for
452 compactness.

453 **4.1.2 Translation of PWG SM into CWMP Data Models**

454 The proposed CWMP PrintService Data Model should be developed as follows:

- 455 a) Define translation rules for the PWG complex datatypes and element groups;
- 456 b) Machine-translate keyword PWG datatypes in “PwgWellKnownValues.xsd” and
457 “MediaWellKnownValues.xsd” into simple BBF ‘string’ and save as control files –
458 the authoritative list of standard values remains in the PWG XML Schema and
459 IANA IPP Registry files.
- 460 c) Machine-translate other PWG datatypes in “ServiceTypes.xsd”, “JobTypes.xsd”,
461 “DocumentTypes.xsd”, and “WimsType.xsd” into simple BBF types when possible
462 and save as a control file – convert ‘choice’ and ‘union’ types into simple BBF
463 ‘string’ or ‘list’ or BBF sub-objects (TBD) – convert ‘sequence’ types into BBF sub-
464 objects.

- 465 d) Machine-translate the PWG elements dictionary in PwgCommon.xsd into a BBF
466 parameter dictionary and save as a control file – preserve integer ranges, string
467 lengths, etc.
- 468 e) Using the control files output from steps (b) to (d) above, machine-translate the
469 PWG SM PrintService XML schema into an equivalent CWMP Data Model – PWG
470 SM simple elements can be translated one-to-one into BBF parameters – PWG SM
471 element groups can be translated into BBF sub-objects – flatten names whenever
472 possible to shorten fully qualified parameter names – do not translate
473 PrintServiceCapabilitiesReady (too volatile) and JobTable.ActiveJobs (for security);
- 474 f) Hand-edit this machine-translated CWMP Data Model in order to fix artifacts and
475 add XML documentation (annotations, comments, etc.).

476 4.1.3 Simple Parameter Datatypes

477 Parameters (elements) in BBF data models cannot be defined with syntaxes of sequences
478 or complex types, so such PWG Semantic Model datatypes should be flattened whenever
479 possible, to improve efficiency over limited bandwidth WAN connections to the ACS, for
480 example:

481 PrintServiceCapabilities.PrintDocumentTicketCapabilites.PrintDocumentProcessingCapab
482 ilities.NumberUp (list of integers)
483 → PrintService.Capabilities.DocumentProcessing.NumberUp (string)
484 – comma-separated list of integers

485 PrintServiceStatus.AccessModes (list of keywords)
486 → PrintService.Status.AccessModes (string)
487 – comma-separated list of keywords

488 4.1.4 Short Parameter Qualified Names

489 Parameters (elements) in BBF data models are always referred to in CWMP operation
490 requests with fully qualified names (similar to XPath), so redundancy in PWG Semantic
491 Model path names should be eliminated whenever possible, to improve efficiency over
492 limited bandwidth WAN connections to the ACS, for example:

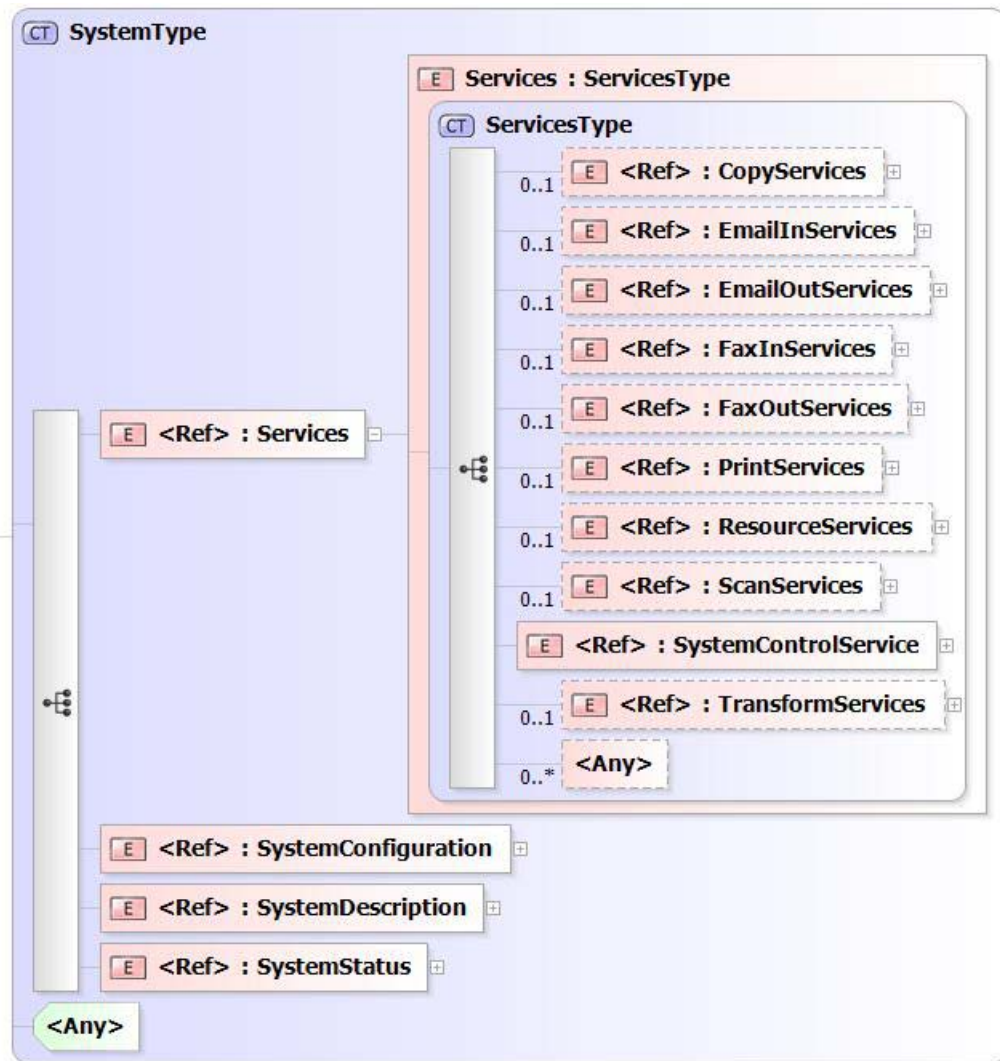
493 PrintService.Configuration.Subunits.InputTrays.InputTray
494 → PrintService.Subunits.InputTray

495 PrintService.Capabilities.PrintJobTicketCapabilities.PrintJobProcessingCapabilities
496 → PrintService.Capabilities.JobProcessing

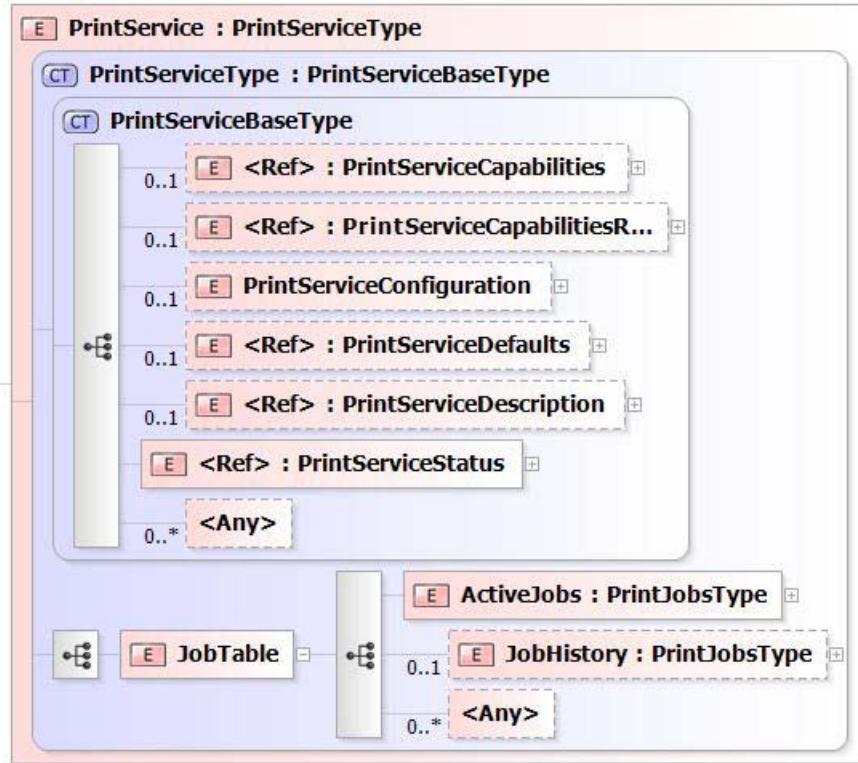
497 Note: Since each CWMP parameter has explicit access mode (readOnly vs. readWrite),
498 PWG SM MarkerSupplyDescription and MarkerSupplyStatus element groups can be
499 safely folded together into the base CWMP PrintService.Subunits.Marker.MarkerSupply
500 object, while preserving the access control distinctions of the PWG Semantic Model.

502 **4.2 PWG SM PrintService Model**

503 The PWG Semantic Model root is the System Object shown in Figure 3 below, which
 504 contains the Services group, which in turn contains the PrintServices group. The CWMP
 505 PrintService Data Model is derived by a transform of the PWG SM PrintService shown in
 506 Figure 4 below.
 507



508
 509 **Figure 3 – PWG SM System Object**
 510

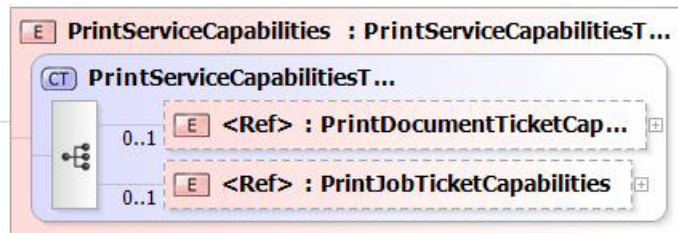


511

512

Figure 4 – PWG SM PrintService Object

513

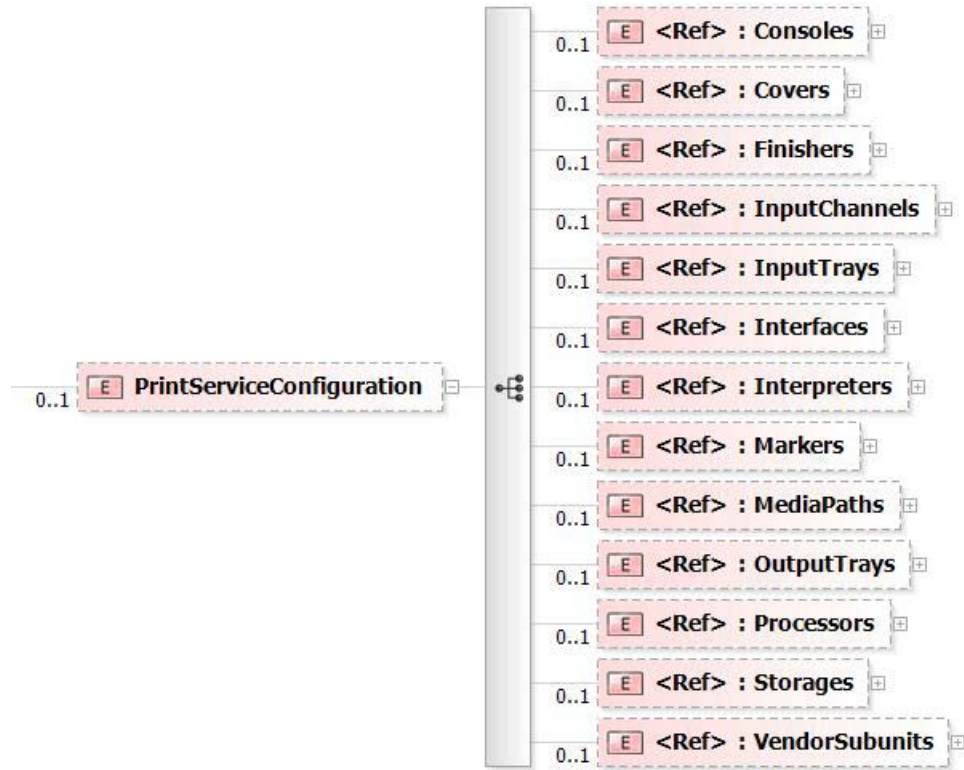


514

515

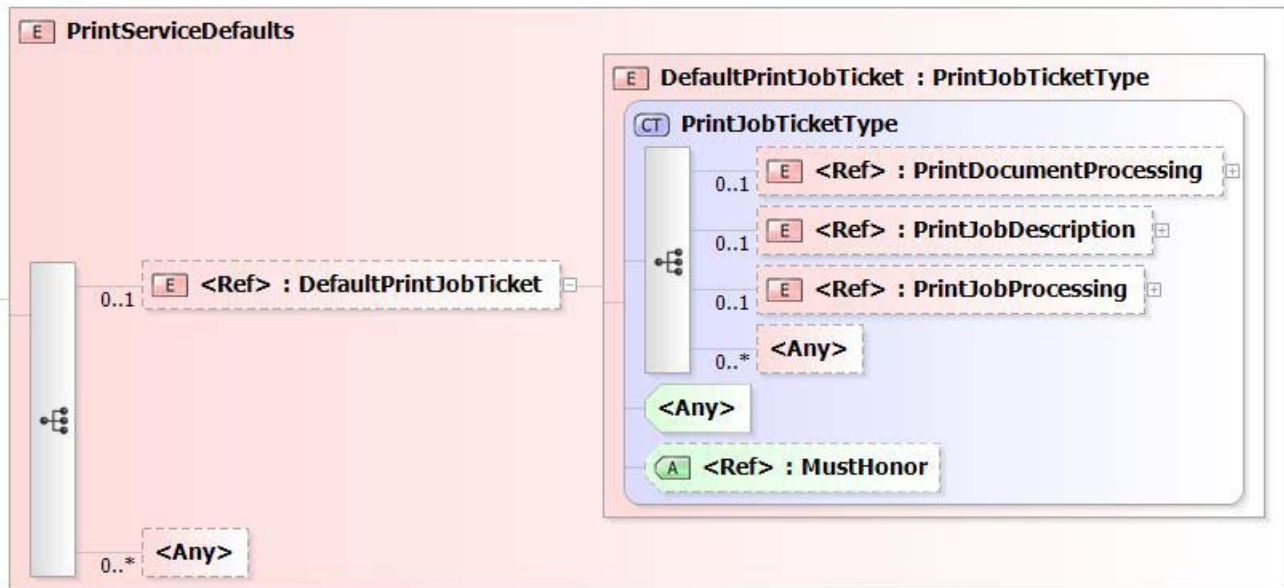
Figure 5 – PWG SM PrintServiceCapabilities Group

516



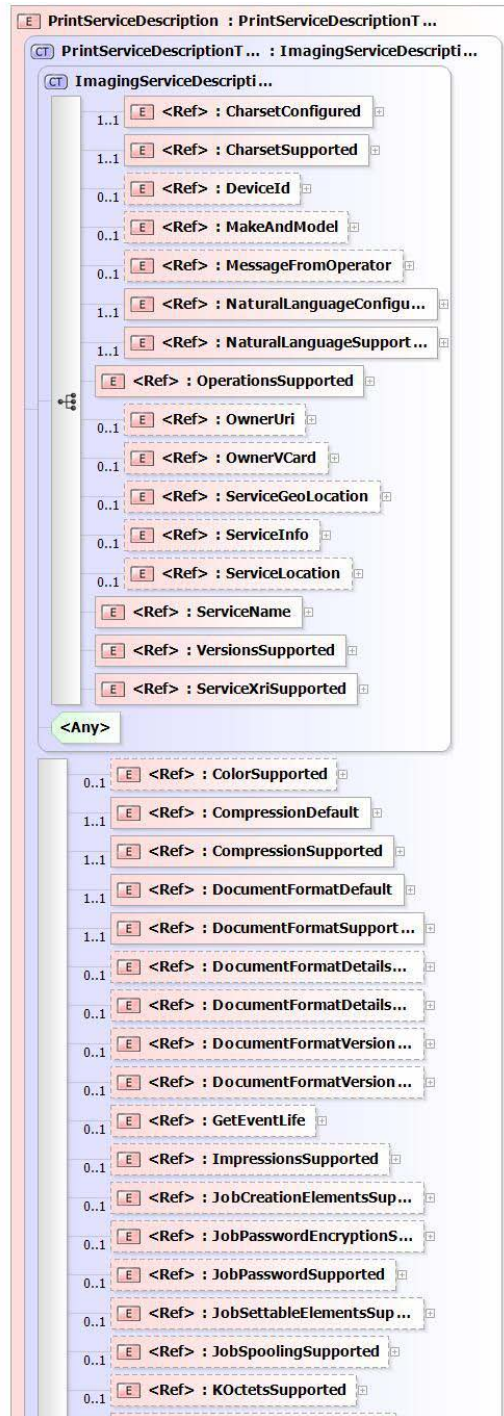
517
518
519

Figure 6 – PWG SM PrintServiceConfiguration Group (subunits)



520
521
522

Figure 7 – PWG SM PrintServiceDefaults Group



523

524

525

Figure 8 – PWG SM PrintServiceDescription Group (excerpt)

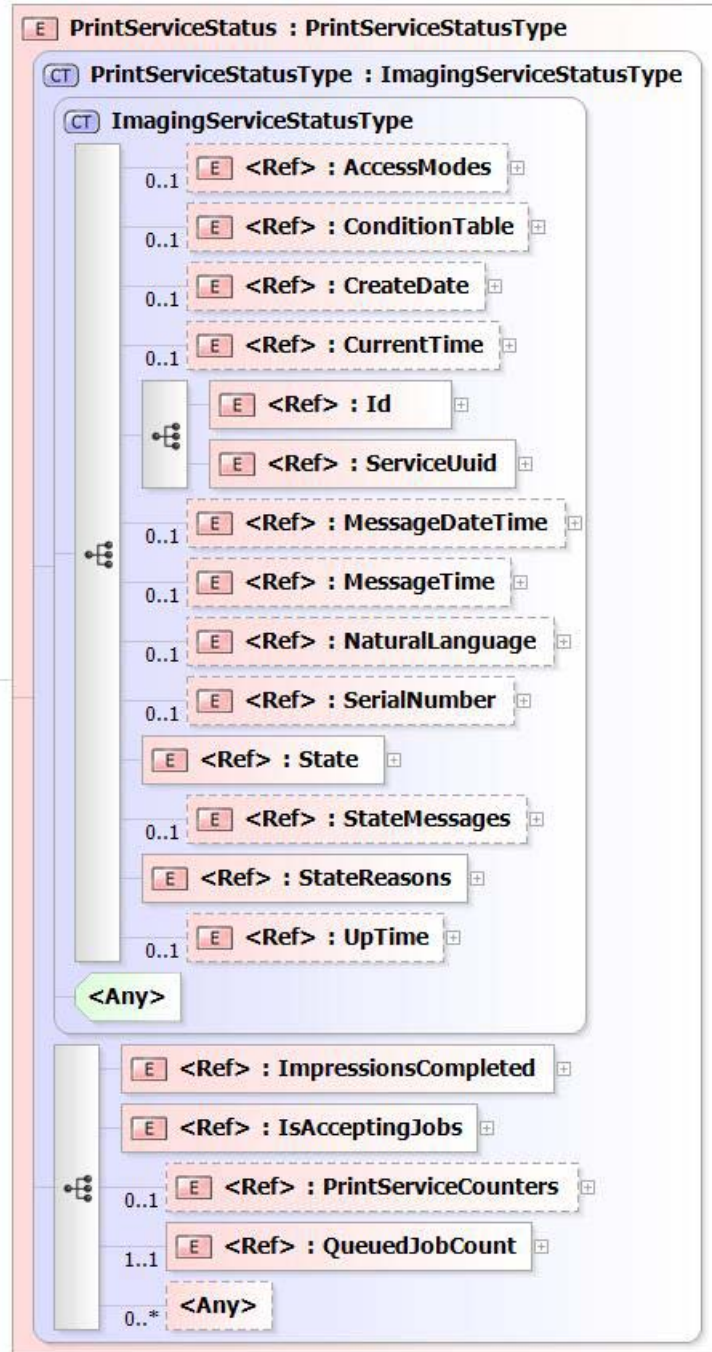
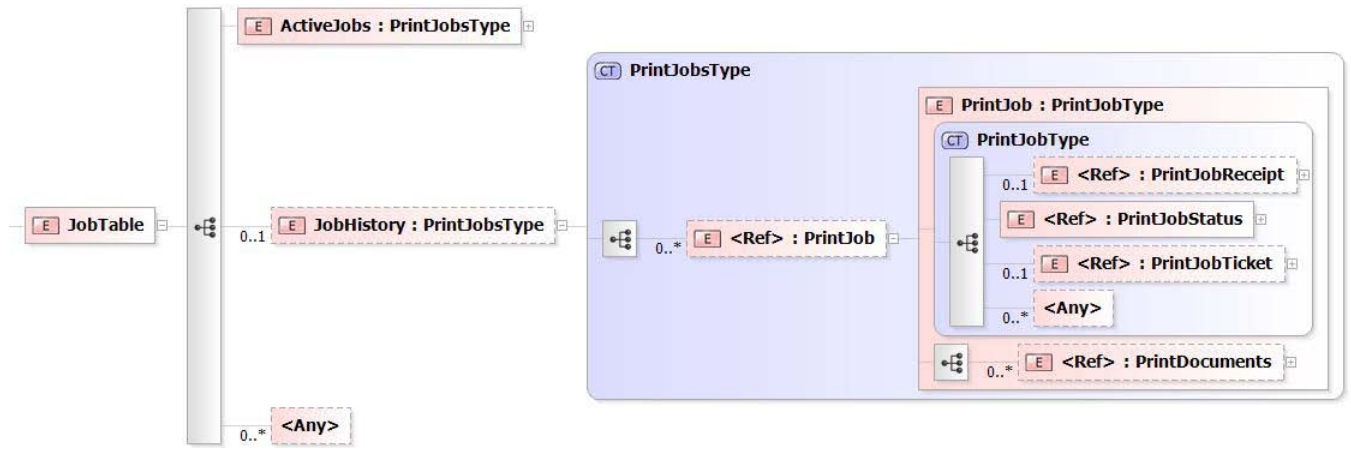


Figure 9 – PWG SM PrintServiceStatus Group

526

527

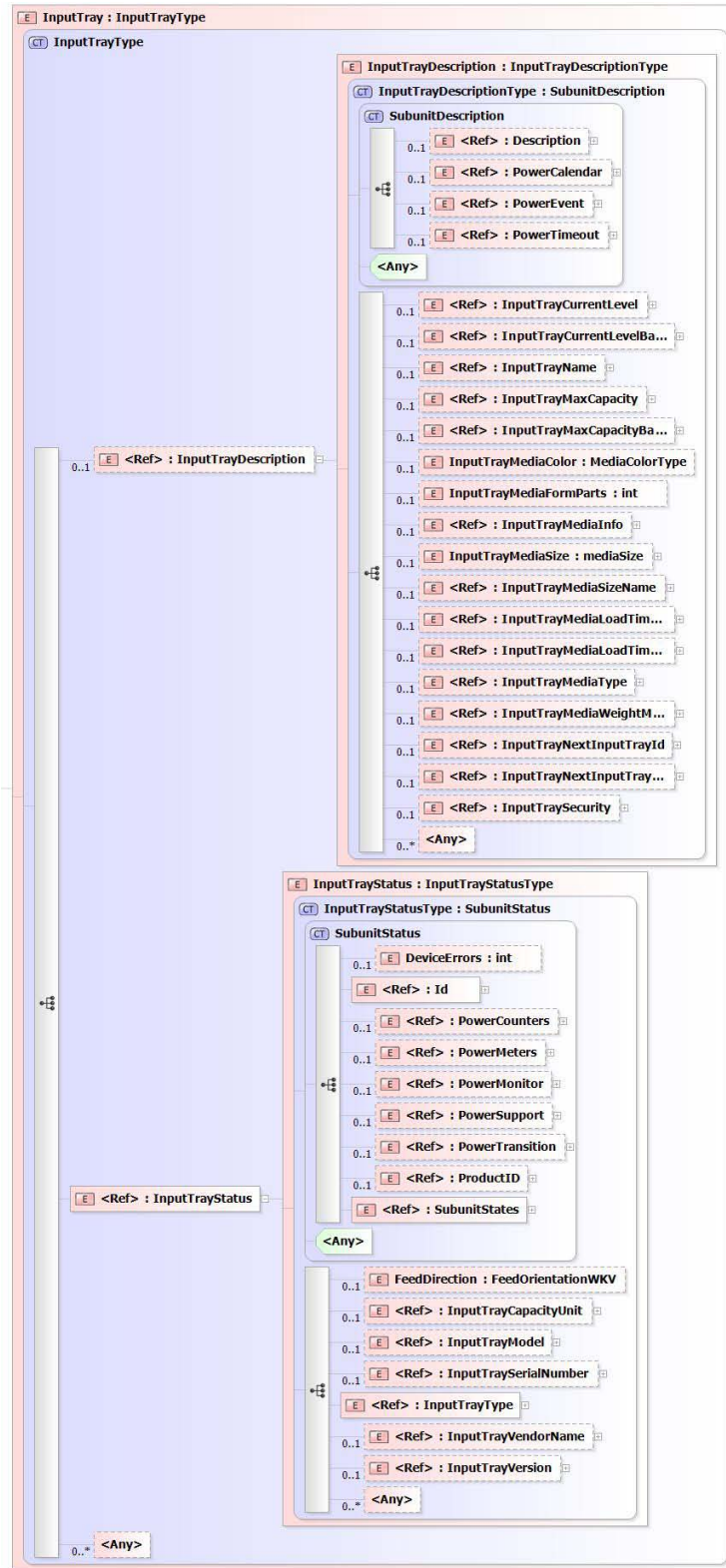
528



529

530

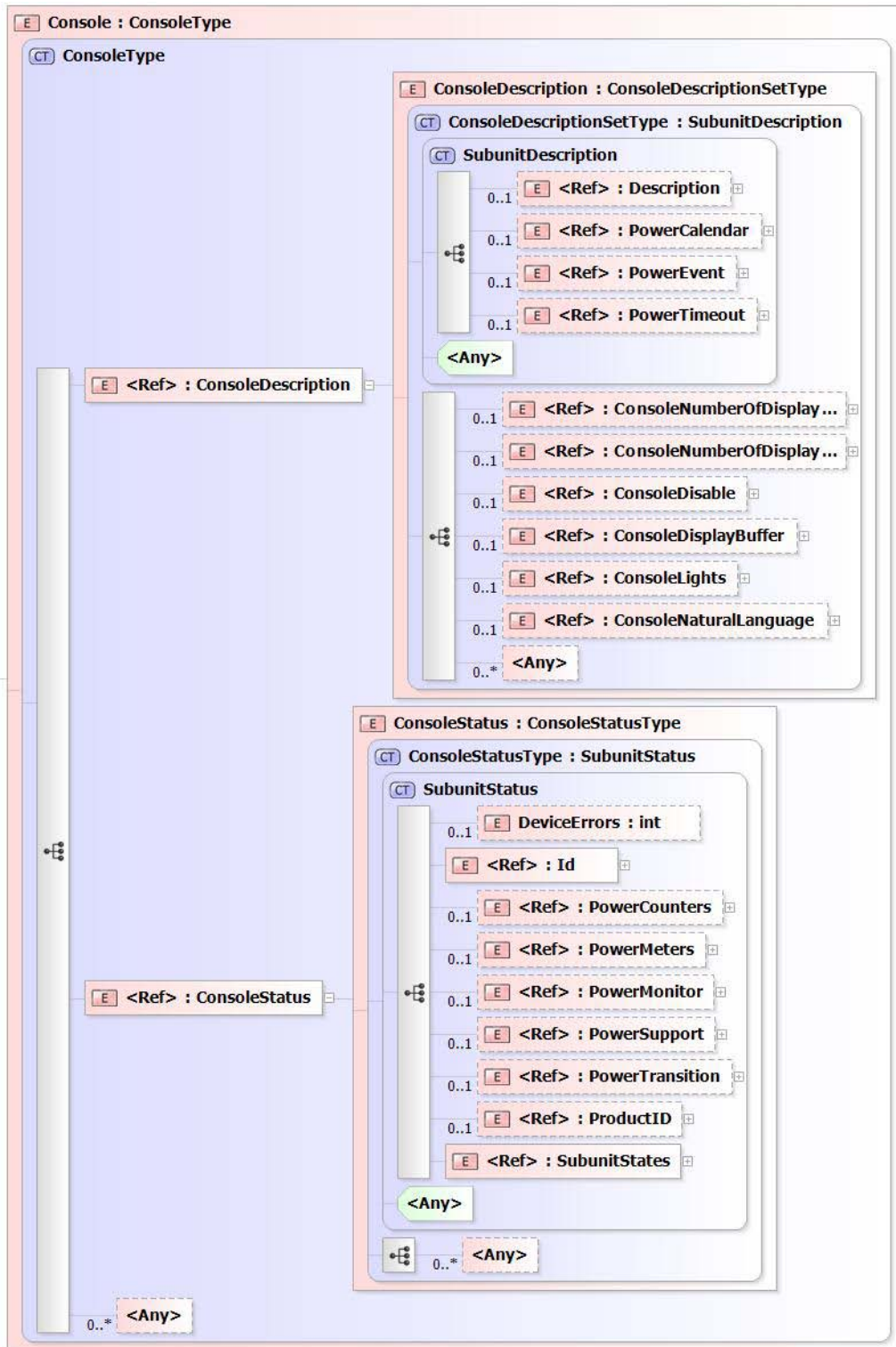
Figure 10 – PWG SM Print JobTable Group (w/ history)



531

532

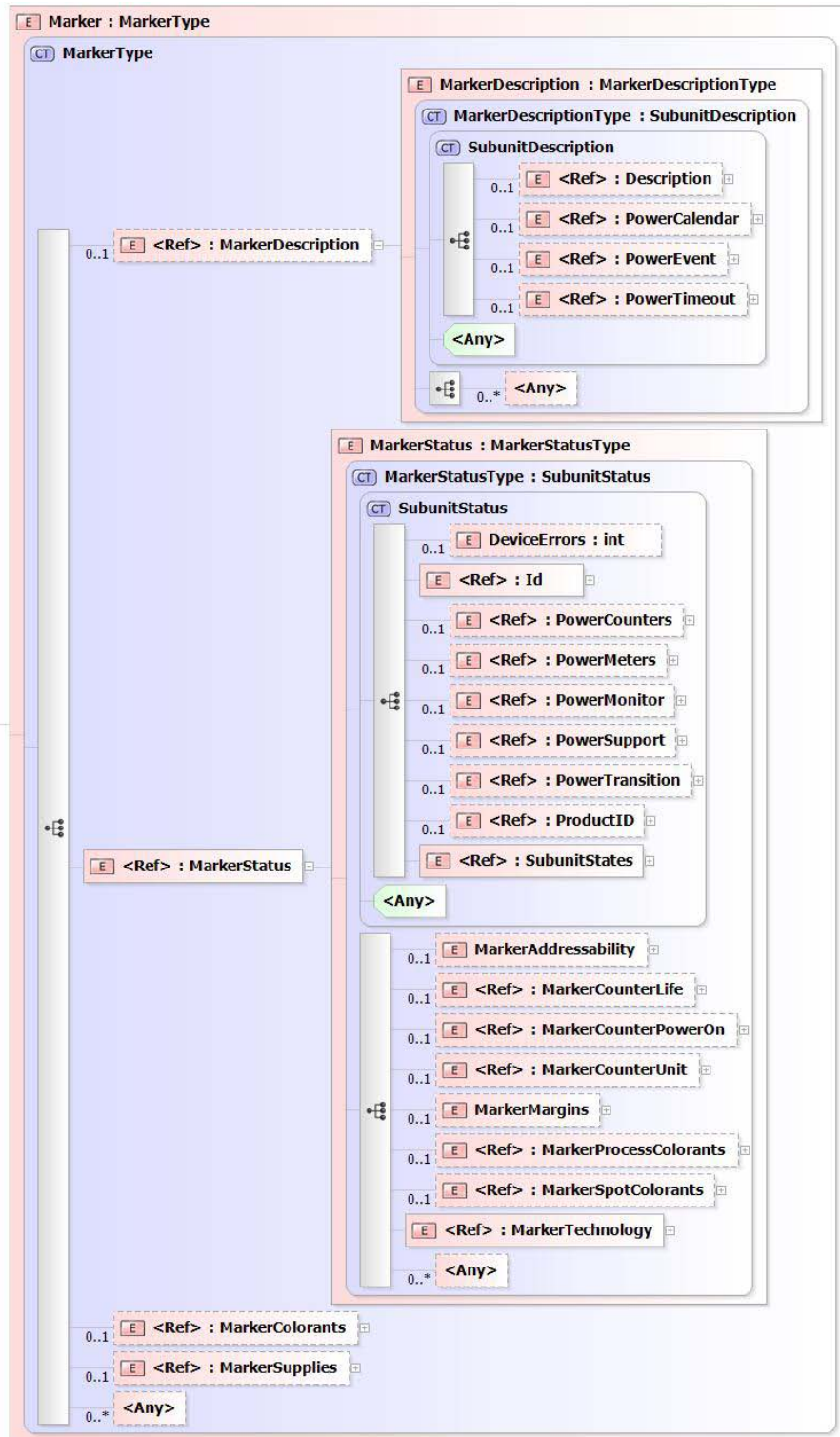
Figure 11 – PWG SM InputTray Object



533

534

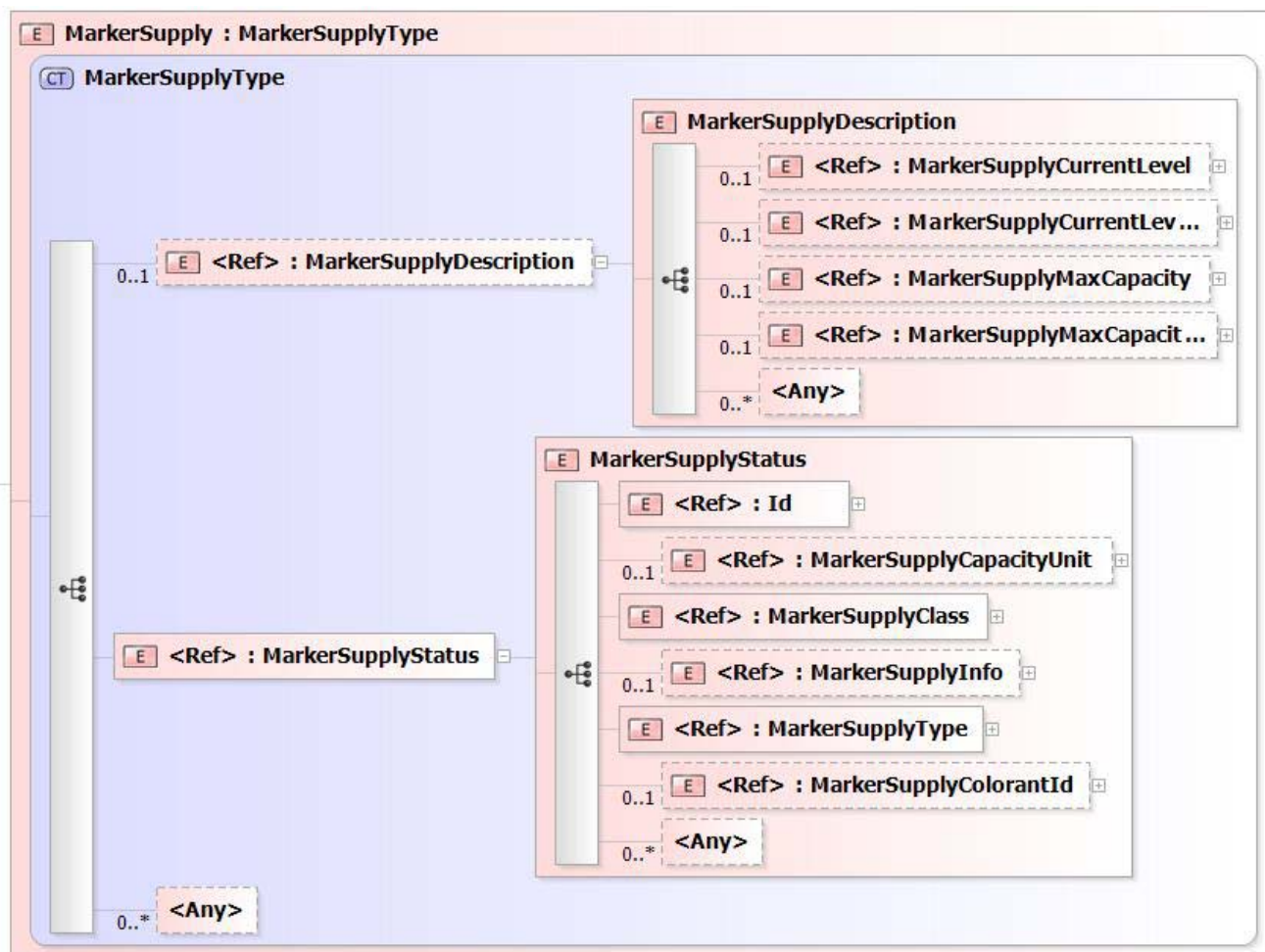
Figure 12 – PWG SM Console Object



535

536

Figure 13 – PWG SM Marker Object



537

538

Figure 14 – PWG SM MarkerSupply Object

539 **4.3 CWMP PrintService Data Model**

540 The following *XML document instance* fragment of a CWMP PrintService Data Model
 541 illustrates the proposed approach and some of the difficulties in transforming the existing
 542 PWG Semantic Model *XML document schema* into a BBF data model [TR-106].

```

543
544 <?xml version="1.0" encoding="UTF-8"?>
545 <!-- TR-999 PrintService:1.0 Service Object definition -->
546 <dm:document xmlns:dm="urn:broadband-forum-org:cwmp:datamodel-1-1"
547 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
548 xsi:schemaLocation="urn:broadband-forum-org:cwmp:datamodel-1-1 cwmp-datamodel-1-1.xsd"
549 spec="urn:broadband-forum-org:tr-999-1-0-0">
550   <import file="tr-069-biblio.xml" spec="urn:broadband-forum-org:tr-069-biblio"/>
551   <import file="tr-106-1-0-types.xml" spec="urn:broadband-forum-org:tr-106-1-0">
552     <dataType name="IPAddress"/>
553   </import>
554   <bibliography>
555     <!-- Set of references here -->

```

```

556     <reference id="TR-135">
557         <name>TR-135</name>
558         <title>Data Model for a TR-069 Enabled STB</title>
559         <organization>BBF</organization>
560         <category>TR</category>
561     </reference>
562 </bibliography>
563
564 <!-- CWMP PrintService model with counter of PrintService instances -->
565 <model name="PrintService:1.0" isService="true">
566     <parameter name="PrintServiceNumberOfEntries" access="readOnly">
567         <description>Number of entries in the {{PrintService}} table.
568         </description>
569         <syntax>
570             <unsignedInt/>
571         </syntax>
572     </parameter>
573
574 <!-- CWMP PrintService object with enable/disable -->
575 <object name="PrintService.{i}."
576     access="readOnly" minEntries="0" maxEntries="unbounded"
577     numEntriesParameter="PrintServiceNumberOfEntries">
578     <description>PWG PrintService in Services in the CPE.</description>
579     <parameter name="Enable" access="readWrite">
580         <description>Enables or disables this {{object}} instance.</description>
581         <syntax>
582             <boolean/>
583         </syntax>
584     </parameter>
585 </object>
586
587 <object name="PrintService.{i}.Subunits."
588     access="readOnly" minEntries="1" maxEntries="1">
589     <description>PWG PrintServiceConfiguration in the CPE.</description>
590     <parameter name="InputTrayNumberOfEntries" access="readOnly">
591         <description>Number of entries in the {{InputTray}} table.</description>
592         <syntax>
593             <unsignedInt/>
594         </syntax>
595     </parameter>
596     <parameter name="MarkerNumberOfEntries" access="readOnly">
597         <description>Number of entries in the {{Marker}} table.</description>
598         <syntax>
599             <unsignedInt/>
600         </syntax>
601     </parameter>
602     <parameter name="ProcessorNumberOfEntries" access="readOnly">
603         <description>Number of entries in the {{Processor}} table.</description>
604         <syntax>
605             <unsignedInt/>
606         </syntax>
607     </parameter>
608     <!-- more number of entries parameters for all subunit tables -->
609 </object>
610
611 <object name="PrintService.{i}.Subunits.InputTray.{i}."
612     access="readOnly" minEntries="1" maxEntries="unbounded"
613     numEntriesParameter="InputTrayNumberOfEntries">
614     <description>PWG InputTray in the CPE.</description>
615     <parameter name="Enable" access="readWrite">
616         <description>Enables or disables this {{object}} instance.</description>
617         <syntax>

```

```

618         <boolean/>
619     </syntax>
620 </parameter>
621
622     <!-- PWG InputTrayDescription parameters -->
623     <parameter name="Description" access="readWrite">
624         <syntax>
625             <string/>
626         </syntax>
627     </parameter>
628
629     <!-- PWG InputTrayStatus parameters -->
630     <parameter name="DeviceErrors" access="readOnly">
631         <syntax>
632             <int/>
633         </syntax>
634     </parameter>
635     <parameter name="Id" access="readOnly">
636         <syntax>
637             <int/>
638         </syntax>
639     </parameter>
640     <!-- more parameter definitions that correspond to PWG SM schema elements -->
641 </object>
642
643 <object name="PrintService.{i}.Subunits.Marker.{i}."
644 access="readOnly" minEntries="1" maxEntries="unbounded"
645 numEntriesParameter="MarkerNumberOfEntries">
646     <description>PWG Marker in the CPE.</description>
647     <parameter name="Enable" access="readWrite">
648         <description>Enables or disables this {{object}} instance.</description>
649         <syntax>
650             <boolean/>
651         </syntax>
652     </parameter>
653     <parameter name="ColorantNumberOfEntries" access="readOnly">
654         <description>Number of entries in the {{Colorant}} table.</description>
655         <syntax>
656             <unsignedInt/>
657         </syntax>
658     </parameter>
659     <parameter name="SupplyNumberOfEntries" access="readOnly">
660         <description>Number of entries in the {{Supply}} table.</description>
661         <syntax>
662             <unsignedInt/>
663         </syntax>
664     </parameter>
665
666     <!-- PWG MarkerDescription parameters -->
667     <parameter name="Description" access="readWrite">
668         <syntax>
669             <string/>
670         </syntax>
671     </parameter>
672     <parameter name="Description" access="readWrite">
673         <syntax>
674             <string/>
675         </syntax>
676     </parameter>
677
678     <!-- PWG MarkerStatus parameters -->
679     <parameter name="DeviceErrors" access="readOnly">

```

```

680     <syntax>
681     <int/>
682     </syntax>
683 </parameter>
684 <parameter name="Id" access="readOnly">
685     <syntax>
686     <int/>
687     </syntax>
688 </parameter>
689 </object>
690
691 <object name="PrintService.{i}.Subunits.Marker.{i}.Supply.{i}."
692 access="readOnly" minEntries="1" maxEntries="unbounded"
693 numEntriesParameter="SupplyNumberOfEntries">
694     <description>PWG MarkerSupplies in the CPE.</description>
695     <parameter name="Enable" access="readWrite">
696         <description>Enables or disables this {{object}} instance.</description>
697         <syntax>
698             <boolean/>
699         </syntax>
700     </parameter>
701
702     <!-- PWG MarkerSupplyDescription parameters -->
703     <parameter name="Description" access="readWrite">
704         <syntax>
705             <string/>
706         </syntax>
707     </parameter>
708
709     <!-- PWG MarkerSupplyStatus parameters -->
710     <parameter name="Id" access="readOnly">
711         <syntax>
712             <int/>
713         </syntax>
714     </parameter>
715     <!-- more parameter definitions that correspond to PWG SM schema elements -->
716 </object>
717
718 <object name="PrintService.{i}.Subunits.Processor.{i}."
719 access="readOnly" minEntries="1" maxEntries="unbounded"
720 numEntriesParameter="ProcessorNumberOfEntries">
721     <description>PWG Processor in the CPE.</description>
722     <parameter name="Enable" access="readWrite">
723         <description>Enables or disables this {{object}} instance.</description>
724         <syntax>
725             <boolean/>
726         </syntax>
727     </parameter>
728     <parameter name="PowerCalendarNumberOfEntries" access="readOnly">
729         <description>Number of entries in the {{PowerCalendar}} table.</description>
730         <syntax>
731             <unsignedInt/>
732         </syntax>
733     </parameter>
734     <parameter name="PowerEventNumberOfEntries" access="readOnly">
735         <description>Number of entries in the {{PowerEvent}} table.</description>
736         <syntax>
737             <unsignedInt/>
738         </syntax>
739     </parameter>
740     <parameter name="PowerTimeoutNumberOfEntries" access="readOnly">
741         <description>Number of entries in the {{PowerTimeout}} table.</description>

```



```

742     <syntax>
743     <unsignedInt/>
744     </syntax>
745 </parameter>
746 </object>
747
748 <object name="PrintService.{i}.Subunits.Processor.{i}.PowerCalendar.{i}."
749 access="readOnly" minEntries="1" maxEntries="unbounded"
750 numEntriesParameter="PowerCalendarNumberOfEntries">
751   <description>PWG ProcessorDescription.PowerCalendar in the CPE.</description>
752   <parameter name="Id" access="readOnly">
753     <syntax>
754     <int/>
755     </syntax>
756   </parameter>
757   <parameter name="RequestPowerState" access="readWrite">
758     <syntax>
759     <string/>
760     </syntax>
761   </parameter>
762   <parameter name="CalendarRunOnce" access="readWrite">
763     <syntax>
764     <boolean/>
765     </syntax>
766   </parameter>
767 </object>
768
769
770 <object name="PrintService.{i}.Capabilities."
771 access="readOnly" minEntries="1" maxEntries="1">
772   <description>PWG PrintServiceCapabilities in the CPE.</description>
773   <parameter name="Enable" access="readWrite">
774     <description>Enables or disables this {{object}} instance.</description>
775     <syntax>
776     <boolean/>
777     </syntax>
778   </parameter>
779 </object>
780
781 <object name="PrintService.{i}.Capabilities.JobDescription."
782 access="readOnly" minEntries="1" maxEntries="1">
783   <description>PWG PrintJobDescriptionCapabilities in the CPE.</description>
784   <parameter name="ElementsNaturalLanguage" access="readWrite">
785     <syntax>
786     <string/>
787     </syntax>
788   </parameter>
789   <!-- more parameter definitions that correspond to PWG SM schema elements -->
790 </object>
791
792 <object name="PrintService.{i}.Capabilities.JobProcessing."
793 access="readOnly" minEntries="1" maxEntries="1">
794   <description>PWG PrintJobProcessingCapabilities in the CPE.</description>
795   <parameter name="JobDelayOutputUntil" access="readWrite">
796     <syntax>
797     <string/>
798     </syntax>
799   </parameter>
800   <!-- more parameter definitions that correspond to PWG SM schema elements -->
801 </object>
802

```

```

803 <object name="PrintService.{i}.Capabilities.DocumentDescription."
804 access="readOnly" minEntries="1" maxEntries="1">
805   <description>PWG PrintDocumentDescriptionCapabilities in the CPE.</description>
806   <parameter name="DocumentDigitalSignature" access="readWrite">
807     <syntax>
808       <string/>
809     </syntax>
810   </parameter>
811   <!-- more parameter definitions that correspond to PWG SM schema elements -->
812 </object>
813
814 <object name="PrintService.{i}.Capabilities.DocumentProcessing." access=="readOnly"
815 minEntries="1" maxEntries="1">
816   <description>PWG PrintDocumentProcessingCapabilities in the CPE.</description>
817   <parameter name="NumberUp" access="readWrite">
818     <description>Comma-separated list of allowed integer values</description>
819     <syntax>
820       <list/>
821     </syntax>
822   </parameter>
823   <!-- more parameter definitions that correspond to PWG SM schema elements -->
824 </object>
825
826 <!-- skip PWG PrintServiceCapabilitiesReady - not interesting over broadband -->
827
828 <object name="PrintService.{i}.Defaults."
829 access="readOnly" minEntries="1" maxEntries="1">
830   <description>PWG PrintServiceDefaults in the CPE.</description>
831   <parameter name="Enable" access="readWrite">
832     <description>Enables or disables this {{object}} instance.</description>
833     <syntax>
834       <boolean/>
835     </syntax>
836   </parameter>
837 </object>
838
839 <object name="PrintService.{i}.Defaults.JobDescription."
840 access="readOnly" minEntries="1" maxEntries="1">
841   <description>PWG PrintJobDescription in the CPE.</description>
842   <parameter name="ElementsNaturalLanguage" access="readWrite">
843     <syntax>
844       <string/>
845     </syntax>
846   </parameter>
847   <!-- more parameter definitions that correspond to PWG SM schema elements -->
848 </object>
849
850 <object name=PrintService.{i}.Description."
851 access="readOnly" minEntries="1" maxEntries="1">
852   <description>PWG PrintServiceDescription in the CPE.</description>
853   <parameter name="CharsetConfigured" access="readWrite">
854     <syntax>
855       <string/>
856     </syntax>
857   </parameter>
858   <!-- more parameter definitions for all PrintService description -->
859 </object>
860
861 <object name=PrintService.{i}.Status."
862 access="readOnly" minEntries="1" maxEntries="1">
863   <description>PWG PrintServiceStatus in the CPE.</description>
864   <parameter name="AccessModes" access="readOnly">

```

```
865     <description>Comma-separated list of access mode keywords</description>
866     <syntax>
867         <list/>
868     </syntax>
869 </parameter>
870 <parameter name="AccessModes" access="readOnly">
871     <description>Comma-separated list of access mode keywords</description>
872     <syntax>
873         <list/>
874     </syntax>
875 </parameter>
876 <parameter name="ConditionNumberOfEntries" access="readOnly">
877     <description>Number of entries in the {{Condition}} table.</description>
878     <syntax>
879         <unsignedInt/>
880     </syntax>
881 </parameter>
882 <parameter name="CreateDate" access="readOnly">
883     <syntax>
884         <string/>
885     </syntax>
886 </parameter>
887 <!-- more parameter definitions for PrintService status -->
888 </object>
889
890 <!-- profile statements - i.e., imported profiles start here -->
891 </model>
892 </dm:document>
```

893

894

895 **5. Conformance Requirements**

896 Provide a list of conformance requirements for the standard.

897 **6. Internationalization Considerations**

898 For interoperability and basic support for multiple languages, conforming implementations
899 MUST support the UTF-8 [RFC3629] encoding of Unicode [UNICODE] [ISO10646].

900 **7. Security Considerations**

901 Provide security considerations for this specification.

902 **8. IANA Considerations**

903 Provide IANA registration information for this specification.

904 Subsections include IANA registration templates using the Example style:

905 Some IANA registration text.

906

907 9. References

908 9.1 Normative References

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997 **11. Change History**

998 **11.1 December 3, 2011**

999 Fourth draft.

1000

- 1001 - Revised Abstract, Introduction, etc., to reflect phased approach – PrintService first,
- 1002 then other Scan, Fax, MFD, etc., data models per CWMP BOF discussions.
- 1003 - Added new section 4.1 Approach to Technical Approach, for clarity.
- 1004 - Added new section 4.2 PWG Semantic Model Print Service, with current PWG SM
- 1005 figures for System, PrintService, all top groups w/in PrintService, and selected
- 1006 Subunits to clarify the mapping.
- 1007 - Moved former section 4.1 to section 4.3 CWMP PrintService Data Model per
- 1008 CWMP BOF discussions.
- 1009 - Revised section 4.3 to remove secondary Device.Config and Device.UserInterface
- 1010 objects – changed to service-centric model of STB (TR-135) and Storage (TR-140).

1011 **11.2 September 26, 2011**

1012 Third draft.

1013

- 1014 - Corrected various typos per Nancy Chen, Ranga Raj, and Laxman J. Bhat.
- 1015 - Revised section 3.2.4 Print Kiosks managed by Telecom Providers to add
- 1016 introduction to Cloud Print use cases and notion of management/provisioning of the
- 1017 Print Kiosks by Telecom providers per Laxman J. Bhat.
- 1018 - Revised section 4.1 MFDSERVICE Model to use correct Secondary Common Objects
- 1019 of Device.Config and Device.UserInterface per Laxman J. Bhat.

1020

1021 **11.3 September 21, 2011**

1022 Second draft.

1023

- 1024 - Revised section 3.1 Rationale to include content from Nancy Chen.
- 1025 - Revised section 3.2 Use Cases to include content from Ranga Raj.
- 1026 - Added section 3.3 Deployment Scenarios to include content from Ranga Raj.
- 1027 - Revised section 4 MFD Data Model for CWMP to explain machine translation.
- 1028 - Revised section 4.1 MFDSERVICE Model to add realistic excerpts from PWG SM.

1029 **11.4 September 14, 2011**

1030 Initial draft.