

Classification of Digital Content, Media, and Device Types

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Abstract

The content we ingest, whether by way of information, communication, or entertainment, is increasingly digital content, appearing as digital media and requiring the mediation of digital devices. The ongoing emergence of new digital media and devices is anticipated, making the stability of their organization uncertain, unless we can devise a faceted approach capable of accommodating future developments. The paper presents a complex and hospitable facet analysis for digital media based on the functions of generation, representation, distribution, and use. For digital devices, a simpler facet analysis emerges, with a primary split between general-purpose devices and task-specific devices; the latter set of devices classes with the task. The Dewey Decimal Classification system is used throughout as a case study.

1 Introduction

If we were to turn the clock back in time, say, 30–50 years, we would find the following modes of communication and distribution of content typical:

- Handwritten notes/letters
- Typewritten business correspondence, using manual typewriters
- Paper files (e.g., card catalogs)
- Books, newspapers, and magazines produced using offset lithography
- Printed mail sent through the postal service
- Still photographs and moving pictures captured using film photography
- Music recordings on vinyl or magnetic tape
- Rotary dial, landline telephones
- Radio and television broadcasting using analog signals

While many of these modes of content communication and distribution survive today, the proportion of content that is recorded digitally has increased over time. In many contexts the modes listed above have largely been replaced by word processing, databases (e.g., OPACs), e-books, online newspapers and magazines, email, digital photography, digital audio, cell phones, digital radio, and digital television. To this list we add other digital-only modes of communication, including Internet telephony, wikis, blogs, webcasting, and podcasting.

Before proceeding, we should address nuances in our use of several key phrases. Our field has long recognized a distinction between the work, which is conceptual/intellectual/artistic in nature, on the one hand, and the embodiment of the work, on the other hand. The same distinction applies between content, which is conceptual/intellectual/artistic, and the embodiment

of that content in various media. Although its syntactic form may lead us to think of “digital content” as a kind of content, in reality it is content embodied in digital form. To avoid confusion we will adopt instead the phrase “digital resource” for a unit of content embodied in digital form. When we refer to digital resources that use the same means for recording and distribution, we will refer to “digital media.”

An interdependency exists between digital resources and digital devices: digital devices make digital resources accessible to our senses; in turn, digital resources provide motivation for digital devices. Wisdom dictates that their subject classification proceed in tandem.

A faceted approach to digital media and digital devices has the greatest likelihood of providing a basis for a stable subject classification, one that does not find itself out-of-date with the creation of each new type. Using the Dewey Decimal Classification (DDC) (2011) system as a case study, the paper investigates which attributes of digital media and digital devices should be used as characteristics of division in a faceted approach and explores their citation order relevance.

2 Developments for digital media and devices in the DDC

The task before us is not limited to digital media (e.g., electronic newspapers) and digital devices (e.g., portable audio players) as primary subjects. Digital media and digital devices are found in the developments of many disciplines throughout the DDC, including, but not limited to, the DDC classes below.

Class number	Context	Caption
004.11–004.16	Computer science	Digital computers
004.69	Computer science	Specific kinds of computer communications
006.4	Computer science	Digital audio
006.5	Computer science	Computer graphics
006.75	Special computer methods	Specific types of multimedia systems
011.39	General bibliographies and catalogs	Electronic resources
025.344	Cataloging, classification, indexing	Electronic resources
070.5797	Publishing	Electronic publications (Digital publications)
302.231	Social interaction / Communication	Digital media
371.334	Schools and their activities / Teaching aids, equipment, materials	Computer science
374.26	Adult education	Use of mass media and computers
384.3	Communications	Computer communication
384.5	Communications	Wireless communication
621.382	Engineering	Communications engineering
621.3911–621.3916	Engineering	Specific types of computers
659.144	Advertising	Advertising in digital media
779	Photography	Photographic images
781.54	Music	Music for specific media

3 Digital media

3.1 Digital media coverage in the Dewey Decimal Classification

Class descriptions and indexing for these media-related developments were processed to produce a list of digital media for which the DDC provides coverage:

Audiovisual materials	Electronic resources	RSS feeds
Blogs	Instant messaging	Serials
Books	Integrating resources	Social media
Broadcast communications	Interactive television	Software radio
CDs (Compact discs)	Interactive videotex	Streaming media
Cellular radio	Internet forums	Telegraphy
Cellular telephones	Internet publishing	Telephony
Chat groups	Internet telephony	Teletex
Computer game music	Machine-readable materials	Teletext
Digital audio	Mobile radio	Television
Digital media	Mobile television	Text messages
Digital publications	Motion pictures	Video recordings
Digital radio	Newspapers	Vide Conferencing
Digital television	Online chat groups	Videotelephony
Digital video	Online social networks	Videotex
Discussion lists	Podcasts	Visual materials
Electronic books	Point-to-point communications	Web publications
Electronic bulletin boards	Radio	Webcasts
Electronic journals	Radiotelephony	Wikis
Electronic mail		
Electronic publications		

Because many digital media have non-digital counterparts, this list includes traditional mass media (e.g., television)—which may or may not be digital—but excludes their subclasses (e.g., Non-commercial television) unless they are specifically digital (e.g., Mobile television). Most synonyms have been filtered from the list. A faceted classification of digital media should account for all of the media listed above.

3.2 Attributes of digital media

While the number of specific digital media types is perhaps unbounded, a significant proportion of the attributes that characterize and distinguish among these media types can be enumerated. For historical reasons, much of the work on isolating such characteristics has taken place in the context of bibliographic description of all types of media types, rather than focusing on the classification of digital media. Despite these differences, the products of such work prove a worthwhile starting point.

We examine the results of three such efforts.¹ The first (see Figure 1) is a lightly revised version of Green and Fallgren's (2007) facet analysis of resource types, based on examining:

- Several developments for resource types within the Dewey Decimal Classification (at 011.3 General bibliographies of works published in specific forms; 025.34 Cataloging, classification, indexing of special materials; 070.57 Kinds of publications; and 302.23 Media [Means of communication])
- General material designations (GMDs) and specific material designations (SMDs) from AACR2; and
- Document types enumerated in wikipedia.org hierarchies.

The second (see Figure 2) is the RDA/ONIX Framework for Resource Categorization (2006), which lists fifteen attributes of resource content, along with the primary values of those attributes. This framework was developed as part of a joint RDA/ONIX project to address the needs of the library and publishing industry communities.

The third (see Figure 3) displays an alignment of:

- Content types for Internet media types as designated by the Internet Assigned Numbers Authority (IANA);²
- RDA's lists of content types³ and media types;⁴ and
- MARC's form of material, category of material, and type of material configurations lists, defined in conjunction with the following fields in the MARC Bibliographic Format, respectively:
 - 006 — Fixed-Length Data Elements — Additional Material Characteristics,⁵
 - 007 — Physical Description Fixed Field,⁶ and
 - 008 — Fixed-Length Data Elements — General Information.⁷

Several types of correspondences given in the RDA and MARC documentation have informed the alignment. These include correspondences:

- between MARC form of material and MARC type of material configurations,
- between RDA media terms and MARC media codes (i.e., category of material), and
- between RDA content terms and MARC type of record (leader/06).

We should note that IANA's content types exist to organize digital media types. They could all have been aligned with MARC's electronic resources and RDA's computer media type. Aligning them as we have done demonstrates that many, but not all, traditional media types

¹ The most recent effort of this type is the BIBFRAME Resource Types Discussion Paper (<http://bibframe.org/documentation/resource-types/20130617.html>), which relies heavily on MARC, MODS (<http://www.loc.gov/standards/mods/>), and RDA for its proposed list of CreativeWork types.

² <http://www.iana.org/assignments/media-types>

³ <http://www.loc.gov/standards/valuelist/rdacontent.html>

⁴ <http://www.loc.gov/standards/valuelist/rdamedia.html>

⁵ <http://www.loc.gov/marc/bibliographic/bd006.html>

⁶ <http://www.loc.gov/marc/bibliographic/bd007.html>

⁷ <http://www.loc.gov/marc/bibliographic/bd008.html>

Figure 1. Green and Fallgren's (2006) Facet Analysis of Resource Types

Facets	Subfacets	Representative values
Content	Subject matter	(open value set)
	Scope [By time period / space / organization]	(open value set)
	Motivation	(open value set)
Generation of content	Authorship	single; multi-author; communal
	Fixity	never changed; with discrete revisions; with continuous revisions; never fixed
Recording of content	Character of content system	language; music; pictorial; machine code
	Method of recording	by hand; electronic; mechanical
	When recorded	
Publication / Distribution	Manner of distribution	distribution of physical medium; electronic download
	Seriality; recurrence	serial: regular; serial: irregular; non-serial
	Quantity of publication run	(open value set)
Physical characteristics	Type of material	(open value set)
	Quality of physical materials	high; average; low
	Quality of data encoding	high; average; low
	Size of material object unit	large; average; small
	Dimensionality	3D; 2D; non-dimensional
	Shape / manipulation	flat; folded; rolled up
	Size of image	reduced; non-reduced; enlarged
Perception / Use	Quality of image	high; average; low
	Sense used in perception	vision; hearing; touch
	External equipment needed for perception/use	none; equipment to project visual images / equipment to process digital visual data / equipment to process digital audio data / equipment to process digital textual data: (open value set)
	Occurrence in time	dynamic: built into material; dynamic: under user control; dynamic: under operator control; static
Relationships	Whole-part	component; member; . . .
	Uniformity	all one thing; combination (as of equals); accompanying (as of a subordinate)
	Relationship to other manifestations of same work	parallel: different registers; parallel: different languages; parallel: different keys; parallel: different instruments; adaptation, condensed; adaptation, extended
	Isolatability	standalone work; work references other works; work depends on other works

admit of digitization. The IANA media types list has historically focused on file formats for email attachments and has now been broadened to include the fuller array of file formats a web browser might be called on to support. Thus, although new digital media types may be added to the list, it will probably never provide an exhaustive list of digital media types.

The alignment in Figure 3 manifests various distinctions important to characterizing types of resources:

Figure 2. RDA/ONIX Framework for Resource Categorization (2006)

Attribute	Primary values
Character	language, music, image, other
SensoryMode	sight, hearing, touch, taste, smell, none
ImageDimensionality	two-dimensional, three-dimensional, not applicable
ImageMovement	still, moving, not applicable
Interactivity	interactive, non-interactive
CaptureMethod	(open value set)
ExtensionMode	succession, integration, not applicable
ExtensionTermination	determinate, indeterminate, not applicable
ExtensionRequirement	essential, inessential, not applicable
RevisionMode	correction, substitution, transformation, not applicable
RevisionTermination	determinate, indeterminate, not applicable
RevisionRequirement	essential, inessential, not applicable
Purpose	(open value set)
Subject	(open value set)
Form/Genre	(open value set)

- audio/hearing vs. video/sight vs. tactile/touch
- language vs. music vs. image
- mediated vs. unmediated (applies to both generation and playback)
 - projected vs. nonprojected (applies to images)
- notated vs. performed (applies to both music and language)
- realistic vs. symbolic representation (applies to images)
- moving vs. still (applies to images)
- two-dimensional vs. three-dimensional (applies to images)
- composite vs. simplex

While some of the attributes identified across these three efforts are unique to one set or the other, others of the attributes occur in two of the sets or sometimes in all three of them. Universally recognized are sensory mode (e.g., audio resources vs. visual resources vs. tactile resources), character of content (e.g., language vs. music vs. image), and dimensionality. All three also recognize that some attributes are relevant only for some kinds of resources (as delimited, for example, by character of content).

As previously noted, the context for these endeavors has been the description of the full range of bibliographic resources, not the classification of just digital resources. Both distinctions—description vs. classification and all-resources vs. only-digital-resources—are of import. As for description vs. classification: (1) Description is concerned with what a work is, whereas classification is concerned with what a work is about. Fortunately, we can reasonably expect that media types recognized in bibliographic description will also be treated as the subjects of bibliographic works. (2) Description seeks specificity, so as to distinguish among resources, whereas classification seeks appropriate levels of generality, to bring together works related by their aboutness. This potentially eliminates the relevance of attributes that apply to only a few resources and those making fine distinctions.

Figure 3. Alignment of IANA, MARC, and RDA Resource Type Categories

IANA Content type	MARC Category of material (007/00)	MARC Form of material (006/00)	MARC Type of material configuration	RDA Content type	RDA Media type
Application	Electronic resource	Computer file / Electronic resource	Computer files	Computer program	Computer
				Computer dataset	
	Notated music	Notated music Manuscript notated music	Music	Notated music (Tactile notated music)	Audio
Audio	Sound recording	Musical sound recording		Performed music	
			Nonmusical sound recording		Sounds Spoken word
Text	Text	Language material Manuscript language material	Books	Notated movement (Tactile notated movement) (Tactile text) Text	Unmediated
	Remote-sensing image				
Image	Nonprojected graphic	Two-dimensional nonprojectable graphic	Visual materials	Still image (Tactile image)	Projected
	Projected graphic				
	Motion picture	Projected medium		Three-dimensional moving image Two-dimensional moving image	
Video	Videorecording				Video
Model		Three-dimensional artifact or naturally occurring object		(Tactile three-dimensional form) Three-dimensional form	
Multipart	Kit	Kit	Mixed materials		
		Mixed material			
Message					

Figure 3 Alignment of IANA, MARC, and RDA Resource Type Categories—cont.

IANA Content type	MARC Category of material / Media code (007/00)	MARC Form of material (006/00)	MARC Type of material configuration	RDA Content type	RDA Media type
	Map Globe	Cartographic material Manuscript cartographic material	Maps	Cartographic dataset Cartographic image Cartographic moving image (Cartographic tactile image) (Cartographic tactile three-dimensional form) Cartographic three-dimensional form	
	Tactile material			Cartographic tactile image Cartographic tactile three-dimensional form Tactile image Tactile notated movement Tactile notated music Tactile text Tactile three-dimensional form	
		Serial/Integrating resource	Continuing resources		
	Microform				Microform
					Microscopic
					Stereoscopic

Limiting our focus to digital resources also changes the picture in various ways, some of which narrow our scope, but some of which broaden it. Huang's (2009) comparative study investigated the applicability of Green and Fallgren's facet analysis to both traditional and digital media covered in the DDC. Differences revealed in the study include the following:

- Network access to digital resources enables both collaborative authorship and continuous revision.
- While sensory mode and character of content are important for both traditional and digital resources, digital resources are the more likely to incorporate content using multiple sensory modes and/or of multiple characters.
- All digital resource content is recorded electronically; that is, none is recorded by hand or mechanically.
- Physical characteristic attributes are, in general, more relevant for traditional resources than for digital resources.
- While some digital resources continue to be distributed as physical media, increasingly they are distributed as digital files over computer networks, via download or streaming.
- File format emerges as an important characteristic for the use of digital resources, but not for knowledge organization purposes.
- Digital resources are more likely than traditional resources to support meaningful interaction.
- Digital resources are, by their nature, mediated, requiring digital equipment for generation and playback.

Taking into account (1) our desired media coverage, (2) past efforts to identify attributes important for resource categorization and (3) differences between description and classification, on the one hand, and between traditional resources and digital resources, on the other hand, we offer the following set of attributes important to the classification of digital resources, including representative values:

Attributes	Representative values
Properties of generation	
Collaborative authorship	Y/N (defaults to N)
Revision	fixed; revised discretely; revised continuously
Properties of representation	
Character of content	language, music, sound, image (multiple values possible)
Dynamicity	notated, performed; still, moving
Dimensionality	2-dimensional, 3-dimensional, non-dimensional
Properties of distribution	
Recurrence	serial, non-serial
Distribution/transmission medium	radio, microwave, cable, optical fiber, satellite, computer network (download; streaming); physical media
Synchronicity of communication	synchronous, asynchronous
Routing	point-to-point communication; broadcast communication
Properties of use	
Sensory mode	sight, hearing, touch, multimedia
Interactivity	Y/N (defaults to N)
Mediation	[equipment needed for playback]

Thus far we have ignored whether the distinction between digital and non-digital media should itself be recognized in a classification of media types. That is, (a) should digital media be grouped together, (b) should a digital/non-digital split be made within media types, or (c) should digital versions class together with, and undistinguished from, more traditional versions of a medium? All three options seem best in some circumstances. Some media types (e.g., wikis) are digital-only; as they lack traditional counterparts, these media types should be grouped together as digital media. But where digital media types have developed by digitizing pre-existing non-digital media types, it makes more sense for the digital media type to be classed with the pre-existing media type, based on shared functionality. But should there be a digital/non-digital split within the overall media type? This depends on the conventionality of the digital medium. When digital media become the norm, as, for example, appears now to be the case with digital photography, enforcing a digital/non-digital split is counterproductive. Thus, a digital/non-digital split should be recognized within each media type only until such time as the digital version becomes conventional. If a digital/non-digital split is initially recognized, but the digital version later gains the status of conventionality, locating the split within the media type has the added benefit of minimizing the effects of relocation after the split is no longer useful.

3.3 Citation order

As noted previously, digital media are found in developments across the DDC. In some cases, a single, non-subdivided class exists for all digital media—for example, 011.39 Electronic resources, 070.5797 Electronic publications (Digital publications), 302.231 Digital media—in the midst of a rather fuller development for more traditional media. (These developments for traditional media, unfortunately, are not always consistent with one another.) A development for digital media exists in 004–006 Computer science—distributed across 004.69 Specific kinds of computer communications, 006.4 Digital audio, 006.5 Computer graphics, and 006.75 Specific types of multimedia systems. A recent proposal approved by the DDC’s Editorial Policy Committee (EPC) will duplicate or mirror that development in other areas of the schedules.

The attributes / characteristics of division that should be highest in the citation order for digital media are those with the widest applicability. These attributes include: mediation, distribution/transmission medium, sensory mode, character of content, and dynamicity.⁸ The next attributes in the citation order should be those whose applicability is neither particularly wide nor particularly narrow: dimensionality, synchronicity, and routing. The last attributes in the citation order should be those with the narrowest applicability, e.g., collaborative authorship,

⁸ We note an interplay among sensory mode, character of content, and dynamicity that, in effect, define several conventional media types:

Conventional media type	Sensory mode	Character of content	Dynamicity
Written language; print media	Sight	Language	“Notated”
Spoken language	Hearing	Language	“Performed”
Published music	Sight	Music	Notated
Music (sound) recordings	Hearing	Music	Performed
Graphic materials	Sight	Image	Still
Motion pictures, videorecordings	Sight + hearing	Image + Sound	Moving

revision, recurrence, and interactivity. The less widely applicable the attribute, the less able we are to fix its location in the citation order.

We explore this citation order in the context of 302.23 in its state before recently approved changes. Only including and class-here notes are shown; had see references existed, they would also have been given.

- 302 Social interaction
 - Class here psychological principles of sociology, interpersonal relations, social psychology
- ...
- 302.23 Media (Means of communication)
 - Including signboards, signs
 - Class here electronic media, mass media, sociology of journalism
- ...
- 302.231 Digital media
 - Including electronic publications, Internet, World Wide Web
- 302.232 Print media
 - 302.232 2 Newspapers
 - 302.232 4 Periodicals and journals
- 302.234 Motion pictures, radio, television
 - 302.234 3 Motion pictures
 - 302.234 4 Radio
 - 302.234 5 Television
- 302.235 Telephony and telegraphy

This development puts all digital media in 302.231,⁹ with traditional media developed in 302.232–302.235.

The proposed development expands under 302.231 for specific digital media with sufficient literary warrant (retaining the order of computer communications as found in 004.69 and 006.75, as well as retaining notes found in the 004–006 development). This development for digital media also relocates digital forms of traditional media to the numbers for the traditional media, as argued for in section 3.2, and relocates multimedia not provided for under 302.231 to 302.2345; specific digital media are added to including or class-here notes, and an expansion is introduced at 302.23445 for Radiotelephony (“Class here mobile telephone systems”).

⁹ “Electronic media,” in the class-here note at 302.23 Media (Means of communication), include both such non-digital media as electronic signs and most traditional, non-print, analog media (e.g., radio, television). “Electronic publications,” in the including note at 302.231 Digital media, primarily include, but are not limited to, digital print media (e.g., e-books, electronic journals).

- 302 Social interaction
Class here psychological principles of sociology, interpersonal relations, social psychology
...
- 302.23 Media (Means of communication)
Including signboards, signs
Class here electronic media, mass media, sociology of journalism
...
- 302.231 Digital media
Including Internet telephony
Class here social media; digital audio, digital video; sociology of the Internet, sociology of the World Wide Web
For online social networks, see 302.30285
Digital media in a specific medium relocated to the medium in 302.23, e.g., online newspapers 302.2322; multimedia not provided for below relocated to 302.2345
- 302.231 1 Electronic mail
Class here instant messaging; point-to-point communications
- 302.231 2 Discussion groups
Class here chat groups, electronic bulletin boards, e-mail lists, Internet forums, newsgroups; broadcast communications
- 302.231 4 Blogs
- 302.231 5 Wikis
- 302.232 Print media
Class here electronic publications [*formerly* 302.231]
- 302.232 2 Newspapers
- 302.232 4 Periodicals and journals
- 302.234 Motion pictures, radio, television
Class here podcasts, webcasts, streaming media
- 302.234 3 Motion pictures
- 302.234 4 Radio
- 302.234 45 Radiotelephony
Including text messaging
Class here mobile telephone systems

302.234 5 Television

Including videotelephony, videoconferencing, telepresence

Class here digital television, interactive television

302.235 Telephony and telegraphy

For radiotelephony, see 302.23445; for videotelephony, see 302.2345

How does this development reflect the proposed citation order? Under 302.23 Media, the first cut is between digital media, print media, and non-print media. Of import here is the characteristic of mediation, with digital media being mediated by digital devices, non-digital print media being apprehended by the human eye, without the aid of equipment, and non-digital, non-print media being apprehended by such electronic devices as projectors, radios, televisions, and telephones. Had the citation order existed before the development, digital media would have been placed after both print and non-print media; it is so placed in some developments (e.g., under 011.3 and under 070.57).

We note that our principle of classing digital media with their non-digital counterparts challenges the overall supremacy of mediation. This principle also makes the structure of developments for print and non-print media relevant to our investigation of digital media. It is to those chiefly non-digital developments that we first turn.

Developments for print media outside 302.23 also include such media as books and pamphlets, with seriality providing the major division between books and pamphlets, on the one hand, and newspapers and periodicals, on the other hand. Physical characteristics such as size and binding or periodicity then come into play for organizing print media.

Various developments for non-print media commonly separate out motion pictures from the rest, on the basis that motion pictures are projected, where radio, television, etc., are not; that is, a more specific characteristic of mediation applies. These developments also group together radio and television, which both traditionally relied on wireless communication; telegraphy and telephony, which traditionally relied on communication via cable or wire, may or may not be grouped together. Here distribution/transmission medium plays an important role.

We see that developments for print and non-print media in the DDC were not guided by a conscious faceted approach, but nonetheless reflect bits and pieces of faceted structure.

Within digital media, we recognize first a division between electronic mail and discussion groups, distributed (originally) via the Internet, and blogs and wikis, distributed via the World Wide Web. Within the former group, we divide on the basis of routing, with point-to-point communications at 302.2311 and broadcast communications at 302.2312; within the latter group, we divide on the basis of collaborative authorship between (originally) predominantly single-author blogs and communally-authored wikis. In addition, blogs are of an irregular serial nature, extended over time by additional posts, while for wikis, although they may also grow over time, being under continual revision is a more important defining characteristic.

The development of digital-only media in the DDC is now sparse enough to allow for a faceted organization to emerge over time. However, as just seen, distinctions that exist when new media first come into being may not persist.

4 Digital devices

While technological advances involving digital media and digital devices have significantly improved ease of access to data and information, their conceptual organization only grows more complex. For example, issues recently raised with respect to the classification of digital devices in the Dewey Decimal Classification (DDC) system include the following:

- Many digital device types are multifunctional. For example, current smartphones may combine the capabilities of a mobile phone, a personal digital assistant, a web browser, a portable device player, a digital camera, and a GPS navigation unit. In the DDC, multifunctional devices are classed with their predominant function. Do all/most digital device types have a clear, stable, and readily discernible predominant function?
- The class 004.167 Handheld computing devices characterizes a type of digital computer on the basis of its size. Is this appropriate when the criterion would fit mini-tablet computers, but not tablet computers? Shouldn't tablets and mini-tablets be classed in the same number?
- What constitutes a computing device? For example, where should e-readers be classed? Are they computing devices, which therefore belong in 004–006 Computer science, or should they be classed, following the rule of application, with electronic publications? For classification purposes, is the Kindle Fire an advanced e-reader or a mini-tablet?

4.1 Digital device coverage in the Dewey Decimal Classification

Class descriptions and indexing for 004.1–004.6 and 621.391 were processed to produce the core list of digital devices for which the DDC provides coverage. To this list have been added representative digital devices associated with the generation, recording, distribution, or use of digital content, for which coverage is also intended, but not always made explicit. (The list is limited to devices providing access to digital content.)

Augmented reality devices (e.g., Google Glass)	Information appliances	Phablets
Barcode readers	Laptop computers	Pocket computers
Camcorders	Mainframe computers	Portable computers
Cell phones	Microcomputers	Portable media players
Computers	Midrange computers	RFID readers
Desktop computers	Minicomputers	Server class computers
Digital audio players	Mobile computers	Smart card readers
Digital cameras	Mobile phones	Smart devices
Electronic book readers	Netbook computers	Smart phones
Electronic organizers	Notebook computers	Smart TVs
Enterprise digital assistants	Palmtop computers	Smart watches
Handheld computing devices	Pen computers	Supercomputers
Handheld game consoles	Personal computers	Tablet computers
Home computers	Personal digital assistants	Wearable computers
	Personal navigation assistants/devices	Workstations

4.2 Attributes of digital devices

The division between computers and non-computers might seem the most fundamental distinction to draw among the digital devices listed above. And yet many of the “non-computers” (a.k.a. information appliances) would qualify as embedded computer systems. The better distinction to draw is between general purpose devices, as, for example, mainframe computers and laptop computers, and devices dedicated to specific tasks, as, for example, camcorders and portable media players.

General-purpose computers have long been categorized by size or processing capacity (a better criterion for supercomputers). The DDC now recognizes these categories of general-purpose computers, starting from those that are the largest / with the greatest processing capacity: supercomputers, mainframe computers, midrange computers, personal computers, and handheld computing devices. Unfortunately, the sizes of smaller computing devices range—more or less continuously—from laptops to smart phones. At what point should we draw the line between personal computers and handhelds? Any line would seem arbitrary and would be likely to produce undesirable results.

For general-purpose computers, we might consider distinguishing between those computers that are mobile and those that are not. But this would put laptops in the mobile category, even though many laptops are big enough and powerful enough to be considered as desktop replacements and thus seem more appropriately classed with personal computers than with other, smaller mobile devices. That is, we tend to run the same kinds of applications on laptops as on other personal computers, because they run the same operating systems. We therefore want our definition of mobile computing devices to be computing devices that typically run mobile operating systems.

For general-purpose computers that do not run mobile operating systems, size / processing capacity remains a relevant characteristic. For general-purpose computers that do run mobile operating systems / are mobile, no further characteristics have yet emerged that warrant representation in the classification system. However, this is where we may expect both the greatest innovation and the greatest literature growth to take place, so vigilance will be needed.

For digital devices dedicated to specific tasks, a digital device should be classed with the task, or, in other words, should be classed with its analog counterpart. Discussion at the end of section 3.2 about digital vs. non-digital resources applies here as well. Thus, digital cameras are classed in 771.3 Cameras and accessories, while cell phones that are not smart phones are classed under 384.53 Radiotelephony.

What of digital devices that are multifunctional? As noted above, in the DDC (see note at 004.11-004.16), multifunctional computing devices are now classed with their predominant function. But do all or even most multifunctional device types have a clear, stable, and readily discernible predominant function across a majority of users? Multifunctional devices tend to be mobile devices. Redefining the class for handheld computing devices in terms of mobile computing devices and classing the majority of multifunctional devices there may prove a multi-problem solution.

Do electronic readers (e-readers) fit into the category of digital devices dedicated to specific tasks or into the category of multifunctional devices? On the surface, the answer is digital devices dedicated to specific tasks. But classing e-readers, following the rule of application, with electronic publications in 070.5797 has proved unsatisfying. After all, such an action is not a matter of classing a digital device in the same number or area as the corresponding analog device—reading books and magazines had not previously required any mediating device at all. Rather than being the digital version of an analog device, the specific task of e-readers is one that was carved out of the functions performed by general-purpose computers. This is in distinct contrast with the tasks performed by digital cameras and cell phones. (Webcams and Internet telephony represent instead functionality added to general-purpose computers relatively late in their development.) Moreover, e-readers are similar in size to mini-tablet or phablet computers; many are able to access the Internet via WiFi; they may include a rudimentary web browser and may serve as a digital audio player or portable media player. Classing electronic readers with multifunctional/mobile devices is probably the better solution.

4.3 Citation order

The issue of citation order is almost not an issue, since we have defined only a small number of characteristics for organizing digital devices. Our first cut distinguishes between general-purpose devices and task-specific devices. Task-specific devices designed as digital counterparts of analog devices are classed with the task; that is, the subject of the task provides the second cut here. General-purpose computing devices are divided by operating system class between those that run mobile operating systems and those that do not. General-purpose non-mobile computing devices should be further categorized by their size / processing capacity. General-purpose mobile computing devices, which typically are multifunctional, may warrant further subdivision; it is not clear yet, however, which further characteristics of division should be applied.

5 Digital media and devices of the future

What advances in digital media and devices will affect the faceted view presented here? While future predictions are always uncertain, two paths forward suggest themselves—extending current trends and addressing current needs.

- Current trends and current needs coalesce in the provision of (preferably free) wireless/mobile access to the Internet in more and more locations, a step toward the “utopia” of ubiquitous computing.
- If various concerns (e.g., security, reliability) can be addressed, data and applications will increasingly be stored and executed in the “cloud.” (This could conceivably lead to the general-purpose/task-specific device distinction giving way to a client/server distinction at the head of the citation order for digital devices.)
- The popularity of social media and user-generated content will continue. The digital devices of the future will link an individual to family and friends, with current location and activity, near-term plans, etc., widely shared among one’s designated circle.

- Devices will need to support collaboration in a variety of contexts. For example, music ensembles from dispersed remote locations could perform live concerts together.
- The percentage of digital devices that are wearable will increase, possibly dramatically.
- Convergence among digital devices will be the norm. The sale of single-function devices like e-readers is on the decline (Bensinger, 2013), given that e-reader apps are also available on devices (e.g., tablet computers) that are only marginally larger, heavier, and more expensive—devices that also permit users to browse the web, take pictures, and play games.

Are we heading toward a future in which a single multifunctional device can “do it all”? But here we face the size conundrum: the device with a screen large enough for scanning across a document (not just reading it side-to-side and top-to-bottom), large enough to watch videos and see details, is too large (and presently too heavy) for tasks like taking pictures and making phone calls. This is the kind of current need that should drive future development. In my imagination, the device filling that need has the ability to project images on a virtual and resizable screen within arm’s reach of the user (allowing input through pointing, swiping, etc.). (For the record, my use of “virtual” means I have no idea how it would operate.)

6 Conclusion

We cannot assume that all major changes in digital media and devices will be continuous with current trends or address currently known needs. But the functional organization of known attributes of digital media under generation, representation, distribution, and use gives us reasonable assurance that new attributes will also be of those kinds. We have seen that values of sensory mode, character of content, and dynamicity—attributes that are universal—combine to define media types. It is (remotely/hypothetically) possible that other values of these attributes might be used in the future (consider, for example, digital scent technology or ESP on the sensory mode side, or haptic communication or neural communication on the character of content side); if so, our faceted structure is already equipped to handle them.

At the same time, new types of resources will likely emerge that could best be distinguished by attributes that are not universally applicable, such as the fairly recent emergence of interactivity and collaborative authorship. This part of the faceted structure will need to remain flexible. But, due to their limited applicability, fixing the place of such attributes in the citation order is not of high importance.

When we come to digital devices, our picture is less settled. Devices that are digital versions of existing devices are classed with those devices. As a result, for purposes of classification development, digital devices are devices that exist only in digital form. They break new ground and may therefore need to be distinguished by attributes that have not been used or recognized previously. Indeed, we have not identified very many attributes for digital devices.

We would like to have set forth a faceted classification of digital media and devices that enumerated all characteristics of division needed and established an overarching citation order. Instead of developing a completely faceted classification, we have identified faceted structures

that support an only partially faceted classification. For digital media, it appears that complex faceted structures are needed, but for digital devices, only simple structures are required for now.

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