

Interoperability Guidelines for the Home Information Infrastructure

Report of the Architecture Breakout Group, NIST Advanced Digital Television Workshop

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In the first of its two meetings the breakout group had a wide-ranging discussion, during which a number of NII-related issues were identified. Broadly speaking, these issues could be classified under the following headings:

- NII vision
- Architecture
- User's perspective
- Digital video and the role of the Grand Alliance
- Integration
- Security and intellectual property issues
- Access modes
- Universal access

Experts on each issue were present, with a total attendance of about 40.

To start the second breakout session, the group conducted a thought experiment in which a hypothetical user purchased a new information appliance (such as a display), took it home and connected it to his home information infrastructure, used the appliance to exchange video information with other appliances within the home, used the appliance to find and view video-based information from external sources at both low and high data rates, and used the appliance to produce locally generated video information for onwards transmission over the NII.

Based on the results of the first two activities, the group identified a number of key NII-ATV Reference

Points that were thought to be essential to NII interoperability. The remainder of this report presents: the context in which the reference points were identified; the individual reference points; and the group's recommendation as to how interoperability (at each reference point) should be achieved. These recommendations include the number of different standards believed to be appropriate for each of the reference points — one, a few, or many.

Reference Points for NII Interoperability

Figure 1 illustrates four broad classes of NII objects:

- Digital information appliances. The individual home and office devices that are purchased by individual users. These include any local networking equipment within the home or office.

- Digital information channels. The means of communication connecting homes and offices to each other, and to service providers that provide application-specific services and switching, such as television, telephony, etc.

- Third-party services. These include the primary information services themselves (e.g., sources of television programs, newspapers, stock tickers, etc.) and other services (such as authentication billing, etc.) that provide the glue that is essential to the smooth functioning of the NII.

- Software and programs. The information objects that flow over the channels and are executed at the service providers and at the customer-based appliances.

Within each of the "bubbles" of Fig. 1 a wide range of competitive solutions will emerge. Within some of the "bubbles" distinctive subarchi-

tectures may be agreed upon by individual industries. For example, the television industry may develop one subarchitecture for digital broadcast channels, while the telecommunications and cable industries each develop and deploy their own competing architectures. One approach is to agree on a single architecture for the standardization of each class of components. However, given the rapid pace of evolution within the underlying technologies, such an architecture is likely to prove outdated long before it is deployed. Our approach is to allow each of the converging industries to continue to evolve at its own pace. NII interoperability is achieved by surrounding each class of objects with a set of NII reference points, as illustrated in Fig. 2.

NII reference points identify key interfaces that should be made public and interoperable. In a small number of cases a single standard for a reference point may be necessary. In other cases individual industries may agree on one or more standards that describe their interfaces at the reference point. Finally, there may be highly competitive reference points at which a large number of *de facto* interfaces are privately developed, but whose specifications are published to facilitate interoperability. Once these interfaces are made public two scenarios for interoperability at a given reference point emerge:

- Conversion. Converters can be developed to facilitate interoperation between objects implementing different interfaces.

- Convergence. Over time, it is likely that the industries involved will converge on a relatively small number of standardized interfaces that are realized at a given reference point.

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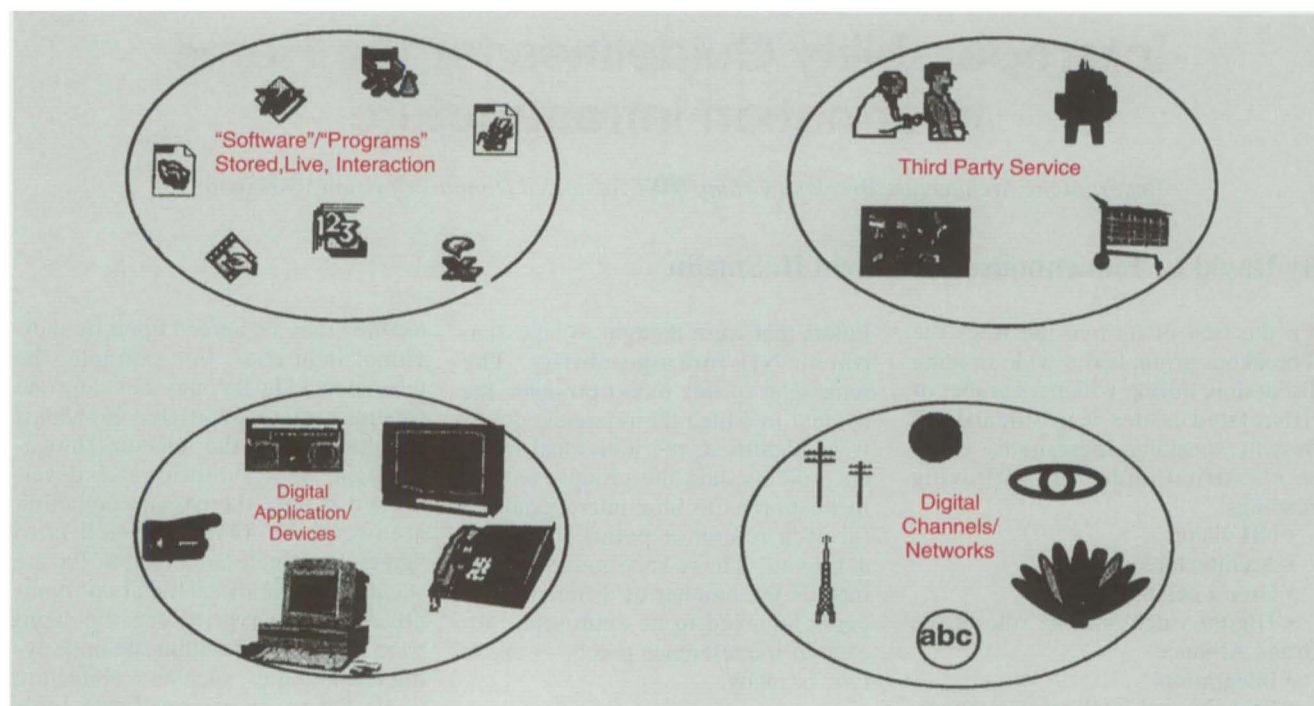


Figure 1. Four classes of NII objects.

NII reference points facilitate interoperability among different implementations of objects of the same class (i.e., different types of devices, different types of digital channels, etc.). They also facilitate interoperability between objects of different classes, i.e., between appliances and channels, or between appliances and programs. Once the reference points are in place a rich mesh of linkages can be developed to suit different NII requirements. For this reason the linkages shown in Fig. 2 are only illustrative — they are not meant to specify or constrain the relationships that might evolve in the future. For example, an information appliance that can be used within the home or office may also be used to manage digital channels or to support third-party services.

Summary

NII interoperability efforts should focus on the identification of key long-lived reference points. Rather than mandate a single standard at each reference point, the NII should adopt a flexible architecture that assumes the interfaces are constantly evolving and that most reference

points will be realized by a variety of detailed standards. The principal requirement for NII interoperability is that a publicly documented interface be made available at each reference point. Market forces will then drive the implementation of the converters and/or convergence that facilitates interoperability.

For each class of NII object the group identified a number of reference points. A total of 13 reference points were identified at the meeting, and this set is likely to evolve as the NII emerges. The following sections discuss the reference points and the group's deliberations concerning them. For each reference point the group considered the following development scenarios:

- Many. At a *many* reference point each vendor develops its own interface and publishes its specification. The reference point serves to delineate the broad functionality common across the interfaces without much restriction as to detail. Interoperability is achieved through converters.

- Few. At a *few* reference point a relatively small number of documented interfaces emerge, either through a *de facto* (survival of the fittest) process,

or due to the adoption of different standards by different industries (e.g., Cable vs. Telco).

- One. A *singular* reference point is a point at which there is a need for a single NII-wide standard.

For the *one* and *few* reference points the group considered whether the emerging standards should be developed through an industry process or through a government-initiated project (with industry involvement). The latter is exemplified by the cooperative manner in which the FCC and the television industry are developing an HDTV standard. Standards proposals are being developed and refined by the industry participants. The standard that finally emerges from this process will be blessed by the FCC.

Digital Appliance/Device Reference Points

Physical Point of Attachment (to the Home or Office Information Infrastructure, or HII)

This is the point at which undifferentiated bits are exchanged between the appliance and the HII. For tethered appliances it is likely to coincide

with a mechanical connector. A variety of digital coding techniques is likely to emerge.

It was the consensus of the group that a few standards should be defined at this reference point through an industry-driven process.

Management Reference Point

HII appliances should be self-describing and software manageable. Each device should include a management information base that describes the device, permits its status to be monitored, and provides for the remote control of its configuration. An example of a standard that supports this functionality is the Simple Network Management Protocol (SNMP). The information made available at the management interface describes the logical interface to the appliance. It may also describe optional or advanced features of the physical interface. A minimal standard for the physical reference point might only support the exchange of bits for management purposes — the detailed description of the physical interface

would be discovered through examination of the management information base. The manufacturer, model number, and serial number should also be available at this reference point.

Although there is strong support for the definition of this reference point, the group was split as to whether there should be a single NII-wide standard or a few industry-driven standards.

Logical Point of Attachment

This is the point at which structured units of information are exchanged through the framing (i.e., packetization) of sequences of bits. The identification of the logical interface implemented by a specific device should be advertised at the management reference point.

The logical reference point will be fluid and competitive with many competing implementations.

Note: Conceptually the digital appliance reference points provide for interoperability among appliances and interoperability between appliances and digital channels. In many

cases this level of interoperability may be supported through a home/office local area network (LAN). Although the HII architecture should provide this level of generality there is consensus that the engineering of individual products may compress the architecture.

Digital Channel/Network Reference Points

There are many classes of digital channels in the NII offering a range of services that support the exchange of bits. Examples of digital channels include ISDN, cable channels, digital broadcast (e.g., Grand Alliance HDTV), fiber to the home, digital satellite, digital cellular, etc.

Physical Point of Presence of the Digital Channel (at the Home/Office Information Infrastructure)

Standards defined at this reference point describe the raw bit interface through which undifferentiated sequences of bits are exchanged at the channel end points.

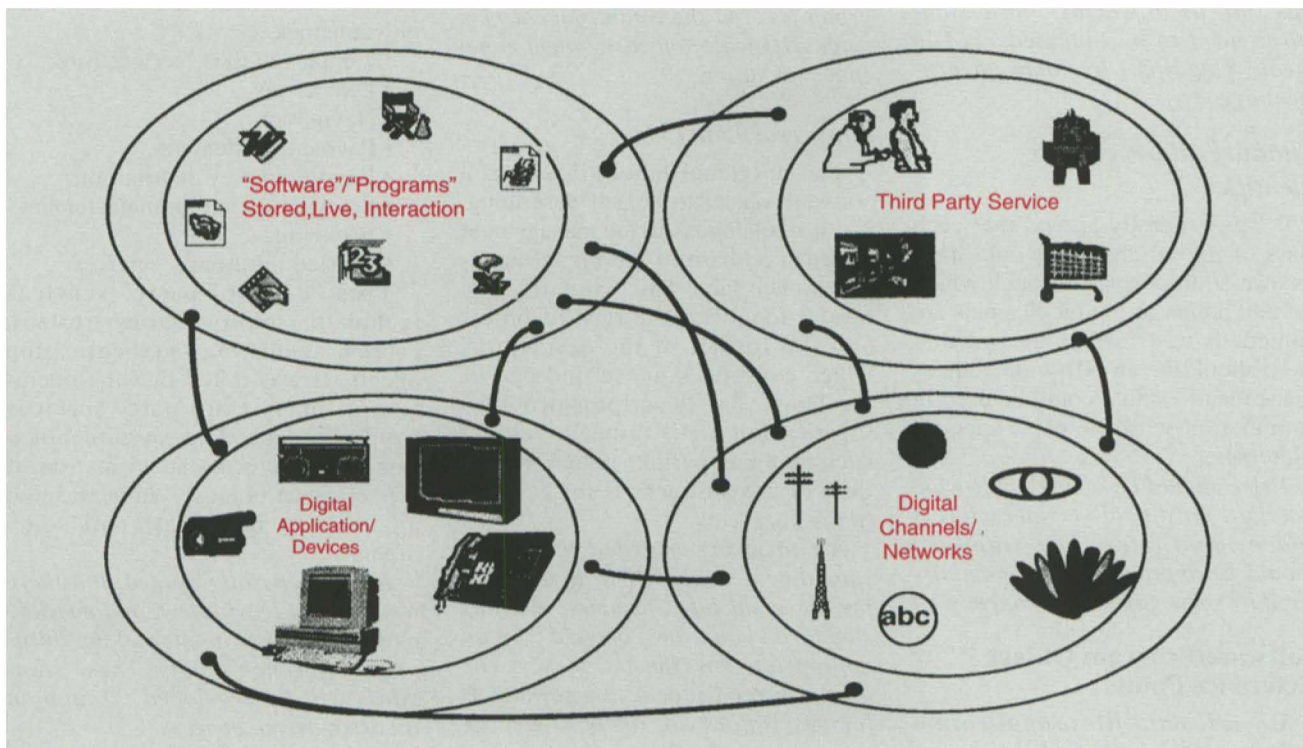


Figure 2. Reference points for NII interoperability.

It was the consensus of the group that there should be one standard for each class of digital channel (i.e., each class of wide area network). The standard used by each class of channel should be defined through an industry-led process specific to that class of channel.

**Physical Reference Point—
Within the Digital Channel(s)**

This reference point describes the coding of bits transmitted within the channel itself (rather than at the end points). Two distinct cases emerge: digital channels involving “enclosed” spectrum (twisted pair, cable, fiber, etc.); and “air” channels that use the shared free-space spectrum.

Enclosed Spectrum. The group was split by a vote of 13 to 9 in favor of a few standards versus a single NII-wide standard at this reference point. It was agreed that the standard(s) should be arrived at through an industry-driven process.

Free Space Spectrum. It was agreed that a single standard should be specified for each class (and band) of digital channel. The group was split as to whether these standards need to be “blessed” (14 in favor, 8 against) by some government agency.

**Channel Address Space
Identifier**

It was generally agreed that each class of digital channel would have its own address space through which the end points of digital channels are named. It was further agreed that there should be an NII-wide address space identifier that could be used in conjunction with the class-specific addresses.

There should be a single NII-wide standard for digital channel address space identifiers. The standard should be approved and/or administered by some government agency.

**Software/Program Object
Reference Points**

Movies, data files, application software packages, and live sport-

casts are all examples of software/program objects.

Software Object Names

This is the point at which the object is assigned a name. The universal resource locators (URLs) used within the World Wide Web are examples of object names. Third-party services may be used to resolve object names into the names of related objects and/or the addresses of digital channel end points.

It was agreed that a few different standards would emerge at this reference point through an industry-driven process.

**Software Object Name Space
Identifiers**

The software object name space identifier is analogous to the digital channel address space identifier. The group was split as to whether or not an NII-wide identifier is required. The contrary position is that the user or program resolving an object name would have prior knowledge as to the standard and registration authority associated with that name.

By a slim margin of 7 to 6 the group favored the establishment of a single NII-wide software object name space identifier.

Universal Label

The universal label allows each software object to be self-describing, i.e., it is analogous to the management information base of the digital appliances. The label has two parts. The header identifies the type of object and the format of the descriptor, which constitutes the second part of the label. The descriptor provides information concerning the object such as the copyright notice, conditions of use, instructions for payment of royalties, etc.

A consensus emerged that there should be a single NII-wide standard for universal label headers, and this standard should be “blessed” by an appropriate government agency. The group agreed that a few standards for descriptors are likely to emerge through an industry-led process.

Media-Specific Formats

Software objects incorporate and manipulate a range of media-specific formats, which can be composed in a number of ways. It was generally agreed that although a wide variety of “data” formats would emerge, a somewhat narrower variety of “audiovisual” formats should be specified. The latter would include both compressed and uncompressed encodings for still images, video, and audio information at a range of resolutions.

A consensus emerged that there should be relatively few standards for audiovisual media encodings and that these standards should be arrived at through an industry-driven process. The group was of the opinion that many different data encodings would emerge through a highly competitive process.

**Reference Points for Third-
Party Services**

Third-party services may be provided by independent service providers or by a “primary” party, i.e., a digital channel provider. These services are identified by software object names.

Examples of these services are:

- Directories
- Navigation
- Payment/settlement
- Encryption key distribution
- Service integration/management
- Brokerage
- Trusted third-party services

Trusted third-party services include those provided by trustees, escrow agents, and authentication agents. It was noted that the operation of many third-party services would be dependent on authentication. Therefore the specification of the reference point for authentication agents may be a matter of some urgency.

It was generally agreed that there would be at least a few, and possibly many, standards at each of the third-party reference points. These standards will be developed through an industry-driven process.