

Expanding the Internet

From moving digital information to
managing it

By

Robert E. Kahn

Corporation for National Research Initiatives

Reston, VA

RDA GlotS Workshop
Geneva, Switzerland
June 6, 2017

What is Special about the Internet Architecture

- Its conceptually simple and minimalist
- Its an open architecture
- Its in the public domain
- Its independent of the various resources and technologies whose interconnection it enables
- The defined protocols and procedures enable it to work
- It has continued to work over a scaling factor of a million

Why Information management?

- The original Internet architecture supported the ability of different network resources to communicate.
- Literally, they were all “things” in the form of information systems.
- But people were still at the helm!
- Driven by fingers on keyboards and eyeballs on screens or outputs from printers/teletypes.
- Most information was ephemeral and either vanished quickly or was very hard to recover later on.

Some of the original challenges

- How to interconnect different packet networks
- How to enable heterogeneous computers to communicate over multiple networks
- How to insulate the users from all the internal details
- How to get programs on different machines to work together (in its most general form, this is still a work in progress).

Some of What we did not address

- Very high speed communications
- Major advances in Information technology
- Big Data
- Serious network based applications
- Needs for persistent access to information
- Ability to interact directly with digital information
- Interoperability between DOs

Why the Digital Object Architecture?

- It provides a framework for managing information of all kinds when represented in digital form.
- Is consistent with the underlying principles of the Internet and is a logical extension of it.
- Enables one to interact directly with the digital objects rather than some aspect of the technology that is used.
- Supports interoperability.

Mobile Programs & Digital Objects

- In mid 1980s, CNRI developed the concept of mobile programs that we called Knowbots.
- Knowbots are, in effect, Digital Objects that can move and are processed by Knowbot Service Stations.
- Although security was enabled through the use of PKI, at the time, fear of viruses, worms and trojan horses discouraged its use.
- The Digital Object Architecture resulted from the Knowbot Information System by not making use of the capability for mobility -- at least at that time.

Basic Concerns

- Storing and Accessing DOs based on use of their unique identifiers
- Resolving a DO identifier to obtain relevant information about the DO, such as where it is stored, or how to validate it
- Understanding the structure of a DO so as to process it
- Discovering DO identifiers

DOIP (also known as DEIP)

- A basic interface protocol that enables a user (or another DO) to interact with a DO based on the use of associated identifiers
- Each action is represented by a DO and the interface conveys the action's identifier (ID1)
- Each target of an action is also a DO and the interface conveys that identifier as well (ID2)
- The formal specification is written as a schema that is incorporated in a program typically run by a repository that serializes structured data.

How can the IoT benefit from the DOA?

- A main goal should be to view every “thing” in digital form as a kind of information system in its own right.
- This can be done by adding a tiny chip to everything.
- This chip implements the DOA by providing
 - a standard external interface based on identifiers;
 - a capability for storing a limited amount of data and metadata in the chip;
 - a means of redirection to an off-chip repository/registry service, when appropriate; and
 - a standardized way to activate a device specific interface to interact with the thing in its native mode of operation.

How does the IoT change things?

- Fundamental changes took place in the Internet as the number of devices exceeded what were then a staggering number – like 100 Million
- Today, it is envisioned that the number of devices in the IoT may come close to 100 Billion in the not too distant future.
- This will stress almost every aspect of the Internet - and especially those that involve information management
- Issues of scalability, performance and graceful degradation must be balanced against the need for architectural changes to provide enhanced defenses.

As IoT Confronts Complexity

- Mobile program technology may soon be needed in the context of implementations of the DOA.
- While techniques like layering or end/end interaction will continue to have utility, a more integrated perspective is appropriate when autonomous devices are widely deployed and are capable of acting on behalf of users or programs to produce desired results.
- The complexities and sheer volume of information that will be available requires a new paradigm for information management
- The evolution of work on mobile programs, as well as recent software implementations of the Digital Object Architecture should provide a sound basis for moving forward.