Logistical Networking for Digital Video on Internet 2

LOGISTICAL COMPUTING AND INTERNETWORKING LAB

http://loci.cs.utk.edu

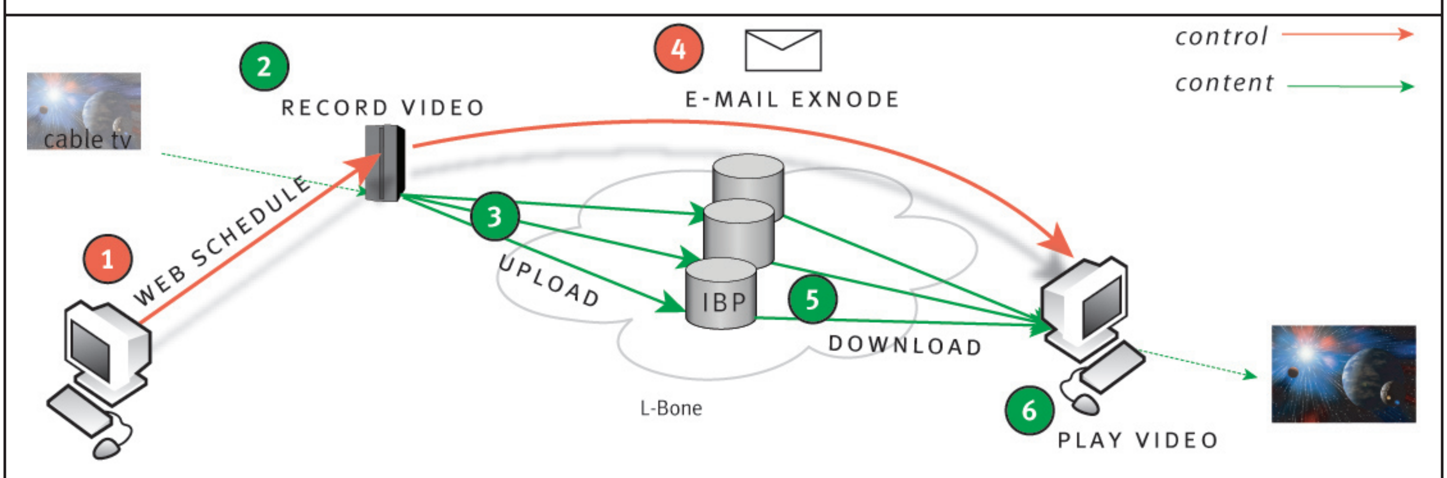
Though digital video has long been an important application area for the Internet2 community, it is on the verge of a new stage in its evolution. The cause of this change is the recent emergence of a new approach to communication infrastructure — *Logistical Networking* (LN). Logistical Networking combines state-of-the-art data transfer technology with storage resources provisioned throughout the network to create a convenient and powerful new paradigm for distributed data management. Although it was developed to support distributed collaboration and large scale applications in the scientific community, there is now a global LN testbed with 20TB of storage available for *anyone* in the research and education community to use, and a set of cross platform tools that make such use extremely easy. The growing deployment of this technology creates rich new opportunities for both ordinary users and application developers who work or play with digital video.

As a simple demonstration of Logistical Networking's potential, researchers at the Logistical Computing and Internetworking (LoCI) Laboratory at the University of Tennessee, where work in LN was pioneered, have developed a prototype application called *IBPvo*. IBPvo is an Internet2-enabled personal video recorder (PVR) service. Like any PVR, such as TiVo or ReplayTV, it can be scheduled in advance to record standard television programs; in the case of IBPvo, the scheduling can be done from anywhere on the Internet through a Web interface. But unlike any other PVR, recorded content is stored in LN "depots" in the network itself. Once a video file is staged in the network in this way, it can be delivered to well connected nodes on global research networks at 100Mbps or better by using multisource/multistream techniques. LN enables ordinary users to get this kind of performance.

As shown in Figure 1, IBPvo achieves such remarkable performance through the combined use of the basic components of LN—the *Internet Backplane Protocol* (*IBP*), the *exNode*, the *Logistical Backbone* (*L-Bone*), and the *Logistical Runtime System* (*LoRS*). A brief look at these components helps make their role in IBPvo and in LN clear.

Internet Backplane Protocol (IBP): IBP is the key enabling technology for LN. It provides a generic, "best effort" storage service that is closely analogous to the generic, best effort data gram service provided by IP. The lightweight, time-limited allocations that IBP depots make available to the entire community create a kind of "working storage" that is both valuable to a wide variety of applications and can scale globally. To preserve this scalability, LN, like the Internet, requires that all services with stronger functionality (e.g. reliability, accessibility, performance) be built "end-to-end" at higher layers of the stack, using services that aggregate best effort IBP allocations underneath. A key point to note is that IBP depots are generic infrastructure, much like IP routers. Since they are designed to maximize the freedom of users and developers to pursue widely different goals using the very same shared storage resources, they can be deployed to serve entire communities.

Figure 1: How does IBPvo work? IBPvo combines all the components of Logistical Networking to enable a user to store and manage media files in IBP depots across the network.



1: IBPvo recording time is scheduled via the web interface.	**3**: LoRS Tools *upload* function is used to upload the video file into IBP storage.	**5**: The user supplies the exNode to the LoRS *download* function.
2: A video file is created using IBPvo's digital VCR functionality.	**4**: An exNode is emailed to the user and acts as a key, granting access to the stored data.	**6**: The user plays the video recording at his/her convenience.

exNode: The exNode is a generalized data structure (analogous to the UNIX inode) that enables IBP allocations to be aggregated to form a “network file.” Encoded in XML for maximum interoperability, exNodes make it easy to use fragmentation, redundancy, and geographical distribution of stored content to implement services that offer more reliability, give faster access, and provide allocations of unbounded size and extended durations.

Logistical Backbone (L-Bone): The L-Bone is a directory and resource discovery service cataloguing registered IBP storage depots. The ever-growing L-Bone currently lists 250+ depots in 20 countries around the world. IBP depots registered with the L-Bone provide information about the amount and type of storage offered, geographical location of the depot, and so on. Clients can then query the L-Bone for depots that have specific characteristics, including minimum storage capacity, proximity, etc. A portion of the L-Bone is the National Logistical Networking Testbed, funded by a grant from the National Science Foundation (NSF) and a donation from Yotta Yotta, a leading Canadian storage company. Other depot nodes are implemented using the resources of PlanetLab, a collaborative research infrastructure located at universities throughout the U.S. and other countries. Current capacity, available to any LN user, exceeds 20TB and NSF support is scheduled to take it to 50TB over the next 2 years. As with the Internet itself, some L-Bone resources are provisioned by the nation’s leading colleges and universities in order to support their own research and education applications.

Logistical Runtime System (LoRS): LoRS is a software suite that brings together the other elements of LN to implement high-level data management including high-performance access, reliability, and end-to-end services such as data compression, checksums, and encryption. With its intuitive graphical user interface (Fig. 2), the newly released LoRS toolkit (ver. 0.82), enables individual users to upload data to and retrieve data from IBP storage, and to manage that data (transfer it between depots, add or delete replicas, refresh leases on allocations, etc.) while it is in the L-Bone. The LoRS tools, which now run natively on all major platforms including Win32, make it easy for any user on Internet2 to move big files quickly.

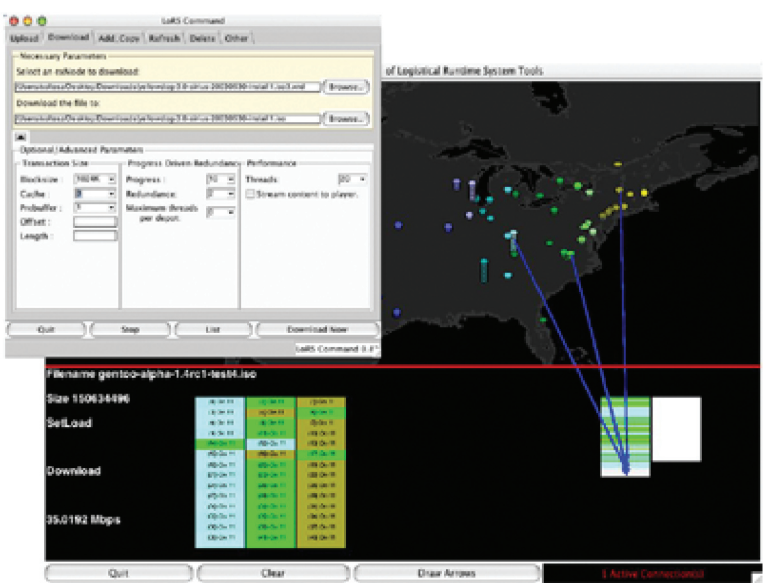


Figure 2: *LoRS download in progress. The LoRS Command window (top left) is an easy to master graphical user interface. The LoRS View visualization window (bottom right) depicts data transfers in real time. LoRS download uses multi-stream TCP to retrieve file content that has been fragmented, replicated, and stored over several IBP depots. The blue arrows at left show file content being simultaneously retrieved from three depots located across the Eastern United States. Since content is replicated on multiple depots, LoRS can automatically maximize download performance by using an algorithm that bypasses slow connections and retrieves content from depots delivering the greatest throughput.*

The technology that makes IBPvo possible is now deployed and ready for any faculty, student, or staff member on Internet2 to use today. The client tools (including a detailed, easy to follow user’s manual) are available for download from http://www.loci.utk.edu. Anyone working with digital video is well positioned to transform the way they work by using these tools. This might include students producing their own videos, IT organizations looking to distribute video content across their state network, or faculty members wanting to use up-to-the-minute foreign language news shows as teaching aides. Together with IBPvo, such applications show that LN is poised to have a powerful impact on the world of digital video.

For more on IBPvo visit http://promise.sinrg.cs.utk.edu/ibpvo/about.htm

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