Communication and Storage of Data for Personal Libraries*

*Personal libraries are proposed by investigating design elements that should be considered in the creation of a **distributed digital object store** for a personal library system. Particular emphasis is placed in **storage scalability** and **communication** demands.*

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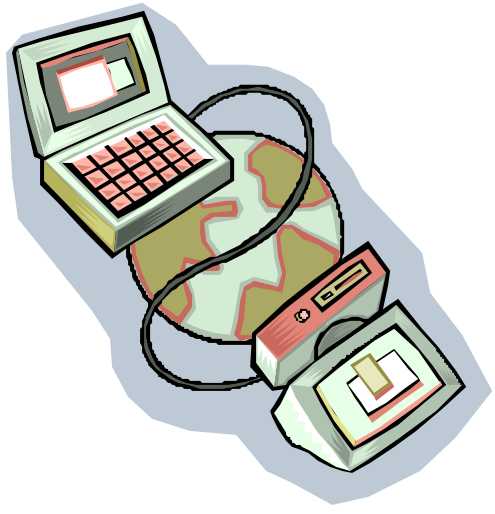
❶Introduction

Personal Libraries: Concept and Challenges

- Vannevar Bush (1945) envisioned a great record of human knowledge
- Bush proposed a collective **“common record”** and **“personal records”** that resided in personal information machines called *Memex*
- Modern *Memex*-like technologies:
  - Personal Computers
  - Digitalization (text, speech, images, and others)
  - Internet
  - World Wide Web (WWW)
  - Digital Libraries



❶Introduction

Personal Libraries: Concept and Challenges

- However, computers dispute the *Memex* role with books, notebooks, sketch pads, adhesive notes and the rest of the paper and ink world!

❶Introduction

Personal Libraries: Concept and Challenges

- While the WWW and distributed★ digital library systems resemble Bush's common record, we have not achieved a uniform concept of personal records
- Modern-day approaches to personal records:
  - the hard drive of my PC?
  - my personal account in a networked file system?
  - a "only client" digital library installation? [e.g. Greenstone, UpLib]

❶Introduction

Personal Libraries: Concept and Challenges

Challenges of personal library technology:

I. To provide the individual user with a general purpose repository★

II. To provide selection of personal library content★ based on:
   a) information-retrieval techniques and
   b) user-defined classification and indexing schemes

III. To provide the user with the capability of accessing her/his personal digital library from anyplace at anytime

IV. To assure long-term archival of library content

V. To grant an interminable storage capacity★ for library content

VI. To allow each user to share the content★ of her/his personal library with other users

VII. To provide interoperability with collective digital library systems and/or the World Wide Web

⇒ ***Effectively a new breed of digital library systems (Borgman, 2003)***

❷Background

Personal Libraries and Digital Object Stores

- A *digital library* can be conceptualized as a collection of services built around digital objects
- *Digital library services* traditionally include:
  - document submission
  - full-text and metadata indexing
  - document search and retrieval
- Libraries are composed of *digital objects* (e.g. documents, technical reports, movies) of several media types (e.g. text, audio, images, video)

❷Background

Personal Libraries and Digital Object Stores

- A digital object has one or more binary representations (e.g. formats) and has associated metadata
- The objects of a digital library reside in a *digital object store*
- Digital object stores can be implemented atop (Mather, 2001):
  - file systems
  - databases with large data objects★
  - digital object repositories

❷Background

Personal Libraries and Digital Object Stores

- Digital libraries require specialized information-retrieval (IR) beyond the retrieval of typed data provided by database technology (Adam et al., 1996)
  - e.g. full-text search
- ⇒ To support full-text search in our digital object store proposal, a *loosely coupled integration* (Raghavan and Garcia-Molina, 2001) of database and text retrieval systems is being followed

❷Background

Personal Libraries and Digital Object Stores

- With mobile technologies and universal access, library systems with tens of millions of users will appear ⇒ architectural changes to:
  - **Communication Services** are critical since:
    - Information Infrastructure → Inherently Distributed
      - Universal Access (III challenge)
      - Content Sharing (VI challenge)
      - Interoperability (VII challenge)
  - **Storage Scalability** is demanded by:
    - +Mobile users, ++Distributed Storage Resources, +++Digital Objects
      - Individual Repository (I challenge)
      - Selection (II challenge)
      - Lifetime Storage (IV challenge)
      - Unlimited Storage (V challenge)

❸State of the Art
Personal Libraries Approaches

- Personal libraries can be categorized according to:

1. Their *personalization* support over their *distribution architecture*★ and

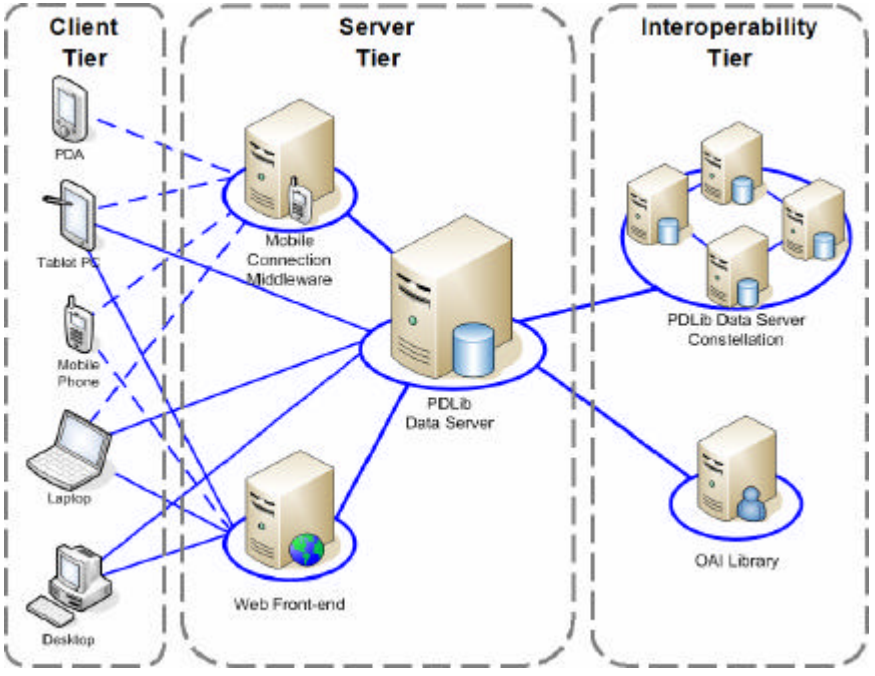
2. Their approach to library *content selection* (Challenge II)

❸State of the Art
Personal Libraries Approaches

- According to their *personalization support* over their *distribution architecture*, personal library systems can be classified as:
  - **Client-side Personal Libraries**. Provide personalization services to the user's interface with the library system (e.g. Daffodil, Paddle, MiBiblio, PoPs, MyLibrary, Salticus)
  - **Peer-to-peer Personal Libraries**. Personal digital library services are provided by the client/server nodes of a distributed peer-to-peer network (e.g. Ding's Semantic Search P2P DL, Guan and Zhang (2004)'s PDL)
  - **Middleware Personal Libraries**. The actual content of the personal libraries comes from *heterogeneous* data sources registered at a mediation environment and mapped to a user-defined schema (e.g. Briukhov et al. (2001)'s Synthesis)
  - **Server-side Personal Libraries**. Personal libraries are provided by the server infrastructure of the digital library system. The server-side approach is specially suited to support access from multiple device types (e.g. Slater's Whisper, He and Shen (2005)'s MyPDL and ***PDLib***, *testbed of this research*)

❸State of the Art
Personal Libraries Approaches

- The main component of PDLib's server infrastructure is the ***data server***★:
  - services for storage, classification and information retrieval of personal library content
  - interaction with other digital library systems via the OAI-PMH
- Other components of PDLib are:
  - **Client-side Applications**. Target mobile and fixed devices adapting digital library services to client device capabilities
  - **Mobile Connection Middleware**. Mediates the interaction of mobile devices with the data server
  - **Web Front-end**. Transforms personal library services into a Web application for browsers and microbrowsers.



❸State of the Art
Personal Libraries Approaches

- Current approaches have focused on the ***client-side***
- Libraries provided by the both the ***client-side*** and the ***middleware*** approach are at odds with the individual repository requirement of personal libraries (Challenge I)
- ***Peer-to-peer*** personal libraries are at odds with the universal access requirement of personal libraries (Challenge III)

❸State of the Art
Personal Libraries Approaches

- Mobile devices place the ***server-side*** approach as a promising alternative to provide universal access (Challenge III) since it facilitates access from multiple device types

- In addition, a digital object store can be readily designed to provide an individual repository to each system user

❹Research Question

- First, it is necessary to specify which IR mechanisms and classification and indexing schemes are considered in this research:
  - **IR Mechanisms**. We propose a distributed IR strategy that combines:
    - *full-text queries* issued to text retrieval systems, with
    - *typed queries* issued to database systems
  - **Classification and Indexing Schema**. This research proposes a *flexible collection and metadata management* (Alvarez-Cavazos et al. 2005)
    - Personal libraries are composed of collections
    - Collections contain, in turn, other collections and/or documents
    - Users interact with personal digital libraries by
      - creating and deleting collections
      - submitting, moving, copying or downloading documents
    - Users can define the metadata set that will be used in each collection

❹Research Question

- Which design elements should be considered by a ***distributed digital object store***
  - *text retrieval systems loosely coupled with*
  - *distributed databases with large objects*
- to satisfy:
  - *the **storage scalability**—required by:*
    - individual repositories (I) with:
      - flexible collection and metadata management (II)
      - full-text and typed selection of content (II) and
      - unlimited storage capacity (V)—*and*
  - *the **communication services**—required by*
    - library content sharing (VI)
- of server-side personal libraries?

❹Research Question
Who is Interested and Why?

- Research in cognitive psychology and information science has shown that individuals (Goh and Kacmar, 1995):
  - Organize, search and retrieve information differently, and
  - Tend to remember where information is located if they are the organizers
- Þ ***We all are interested in personal libraries!***

❺Preliminary Results

- The preliminary results of this research are:
  - ① The design of a centralized digital object store for server-side personal libraries and its prototype implementation in the context of our testbed: the data server of the PDLib system
  - ② The design of the loosely coupled integration architecture of text retrieval and database systems for the storage of personal library digital objects according to our proposed IR strategy

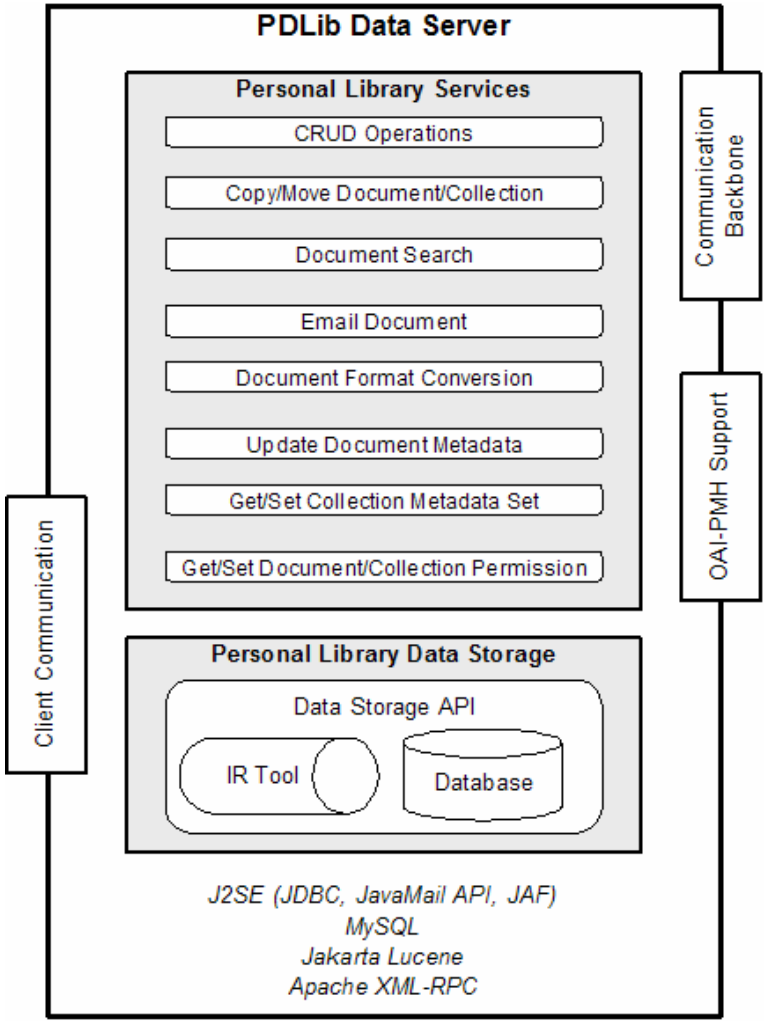
❺Preliminary Results

- ③ A design strategy to address the storage scalability and communication requirements of server-side personal libraries based on:
  - **Data compression** (). To reduce the storage demand of a digital library's data objects
  - **Data integration** (). Will harness storage resources of distributed data sources to address storage scalability
  - **Data communication** (). Provide a communication backbone in order to satisfy the library content sharing

❺Preliminary Results

① Centralized Data Server: Design and Implementation

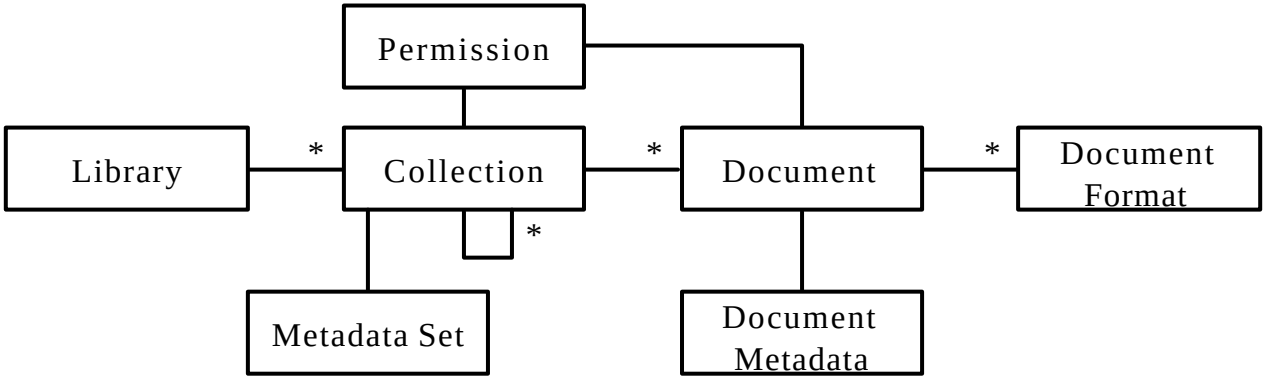
- The data server is the digital object store of the server-side personal libraries provided by the PDLib system
- The data server provides personal library services, stores personal library data and supports interoperability via the OAI-PMH[1]



[1] OAI-PMH support was developed in the context of an associated master thesis (Hurtado-Alvarado, 2005)

❺Preliminary Results

① Centralized Data Server: Design and Implementation



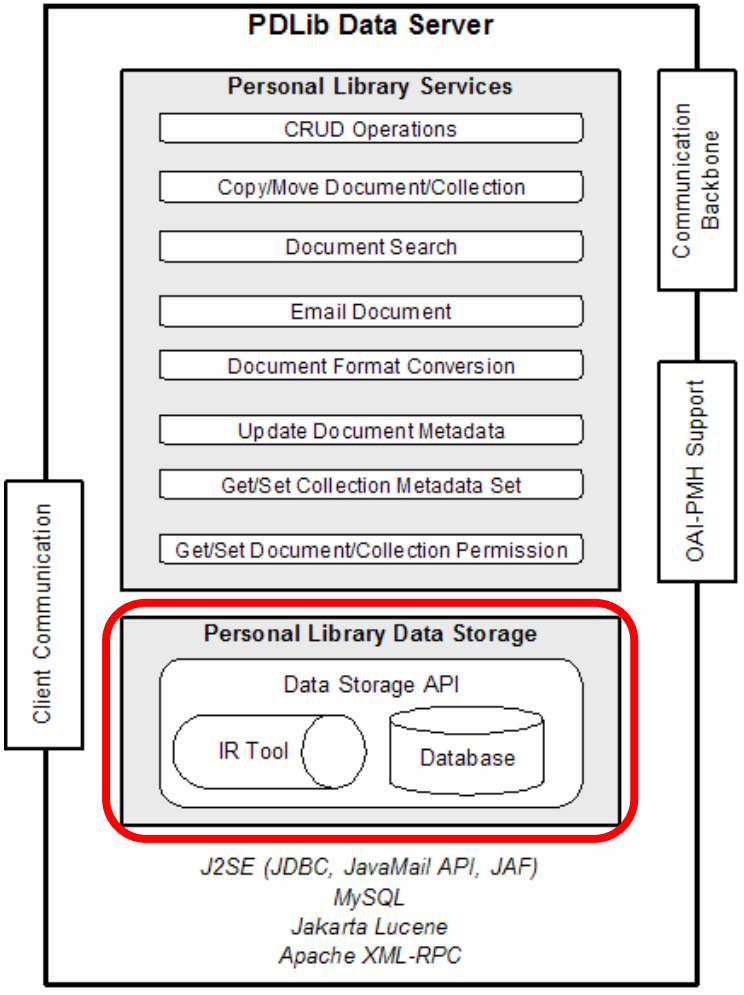
Personal Digital Library Data Model:

- A library contains one or more collections
- A collection contains documents or more collections and is associated with a metadata set
- Metadata sets are composed by one or more metadata definitions
- Document metadata is the metadata of a particular document
- Both collections and documents have associated permissions
- A document can have one or more document formats

❺Preliminary Results

② Data Storage Architecture: Design[2]

- An architecture to provide structured storage with scalable text information retrieval (IR) capabilities for personal digital libraries has been designed
- The data server's data storage component maps the data model (*collections, document formats and document metadata*★) to:
  - Relational Model (tables, rows, columns, data types)
  - Lucene's IR index structure (indices, documents, fields, text domain)

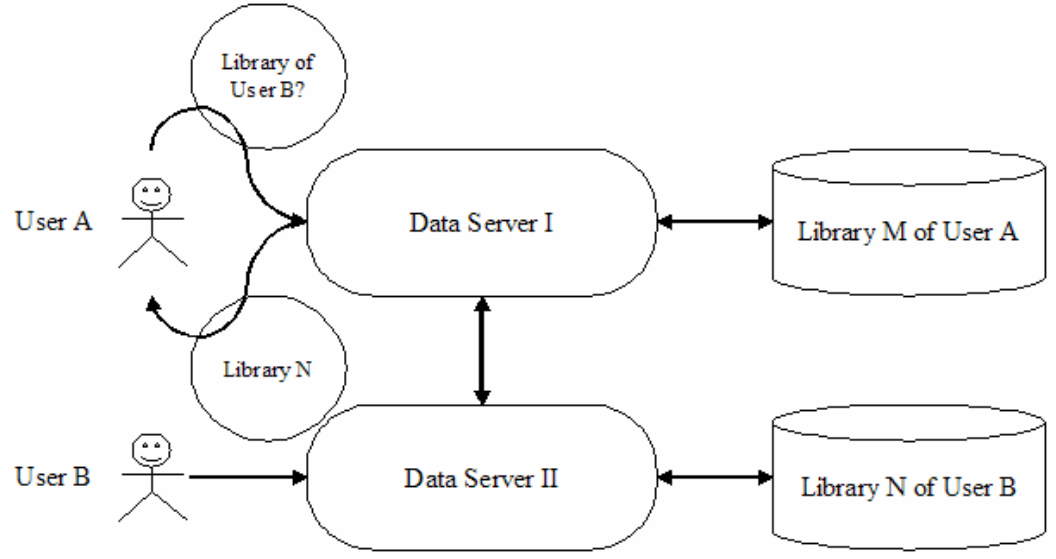


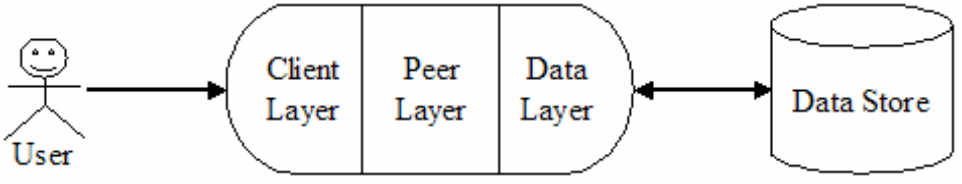
[2] Centralized implementation is underway in the context of an associated master thesis (Hurtado-Alvarado, 2005)

❺Preliminary Results

③ Data Server Future Design Strategy

- The data server is divided into design units:
  - ***Client Layer.*** Set of services accessible by a user ( )
  - ***Peer Layer.*** Communicate with other data servers if it is so required by the user's query ( )
  - ***Data Layer.*** Read and write data in the data store (centralized or distributed) ( )

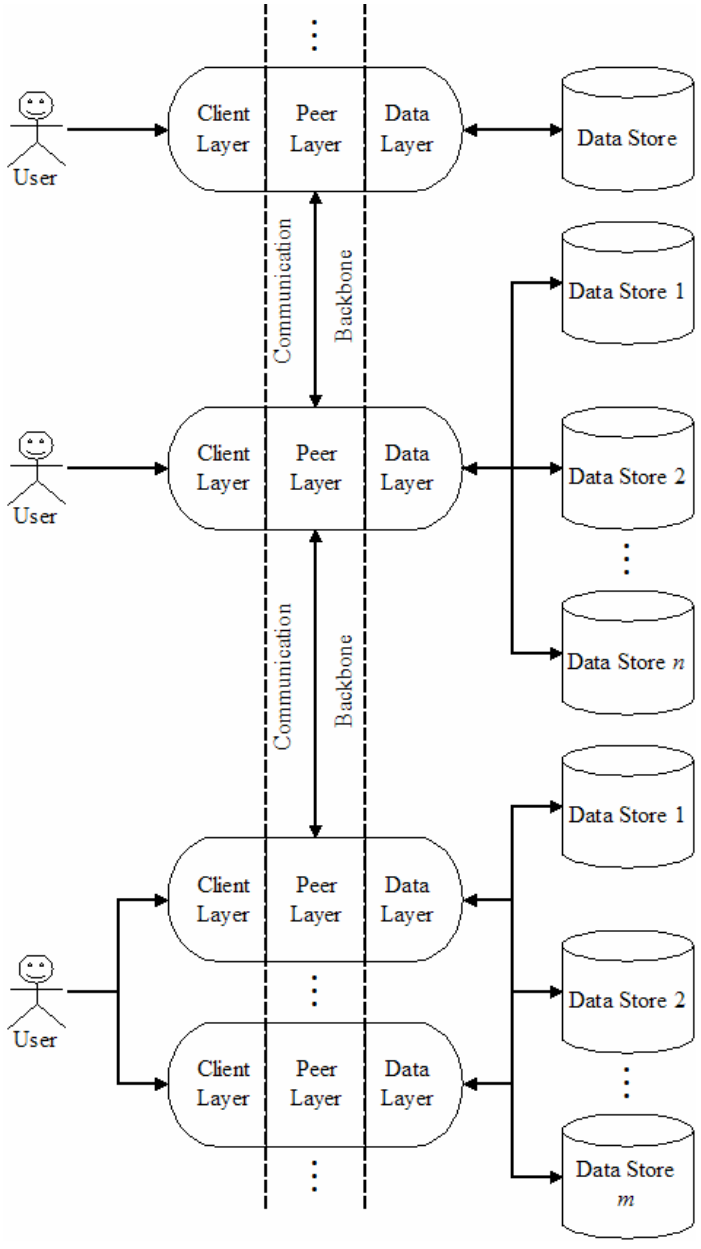




❺Preliminary Results

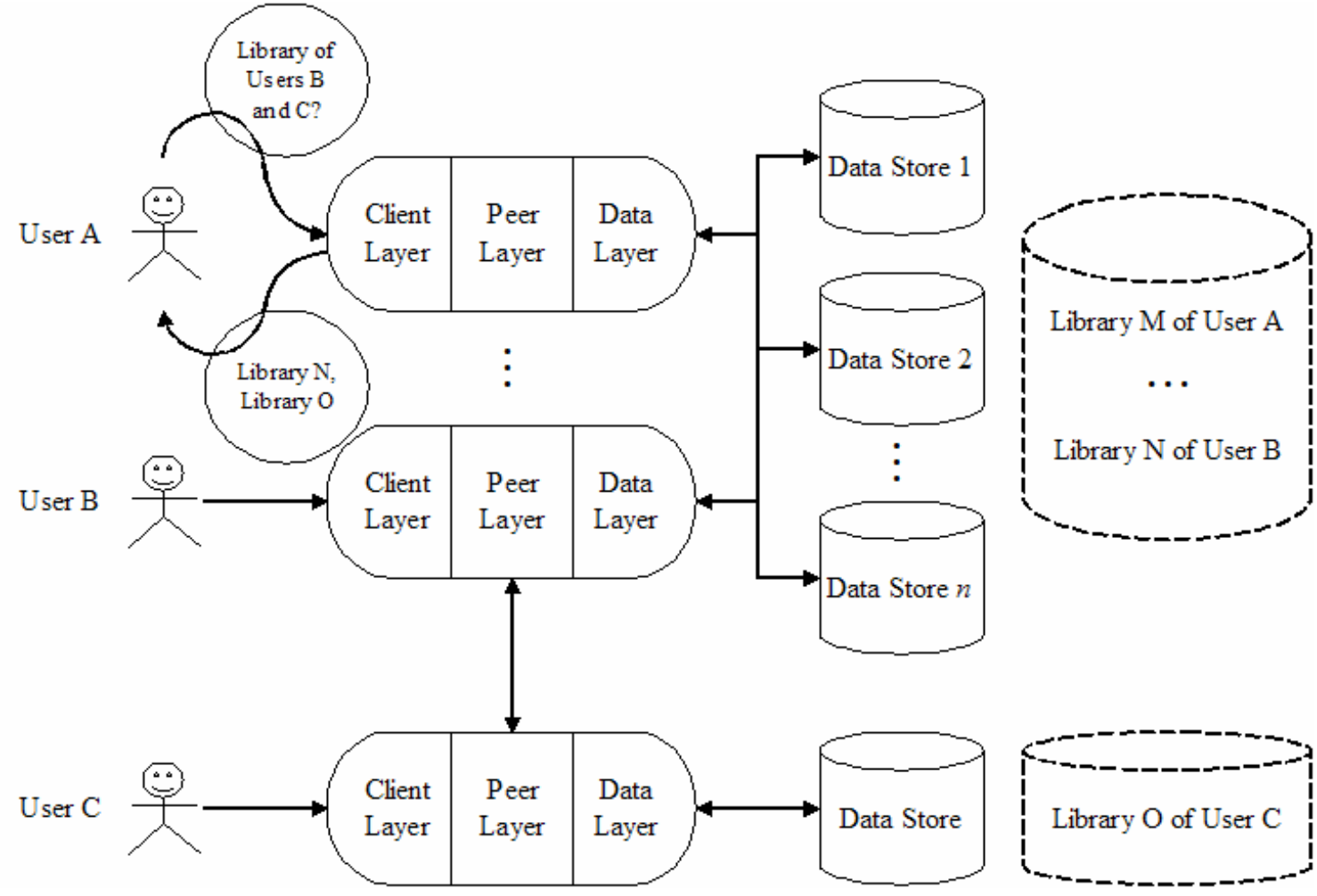
③ Data Server Future Design Strategy

- The peer layer establishes the system's communication backbone
- If two or more data servers access the same distributed database, they shall not interact directly via the peer layer since we expect higher communication performance at the data layer (, , strategy)



❺Preliminary Results

③ Future Design Strategy: The Data Server in Action!



❻Methodology

- This research follows the ***engineering paradigm*** of computer science (Wegner, 1976)

- Three-phase trial-error/success approach:

  1. Trials = ***development*** of the concept implementation of design; Error/success = agreement with functional requirements

  2. Trials = ***capacity characterization*** models; Error/success = model's accuracies

  3. Trials = ***Optimization*** of the concept implementation after capacity characterization feedback; Error/success = performance improvement

❼Expected Contributions and Technical Innovations

- The expected contributions of this research are:
  - The **reference architecture** and **concept implementation** of the
    - data compression
    - data integration and
    - data communication
  - mechanisms of a distributed digital object store, deployed over
    - text retrieval systems loosely coupled with
    - distributed databases with large objects
  - for server-side personal libraries with:
    - flexible collection and metadata management
    - full-text and typed selection of content
    - unlimited storage capacity and
    - library content sharing

❼Expected Contributions and Technical Innovations

- This research leads to the following technical innovations:

1. A scalable, distributed digital object store for server-side personal libraries

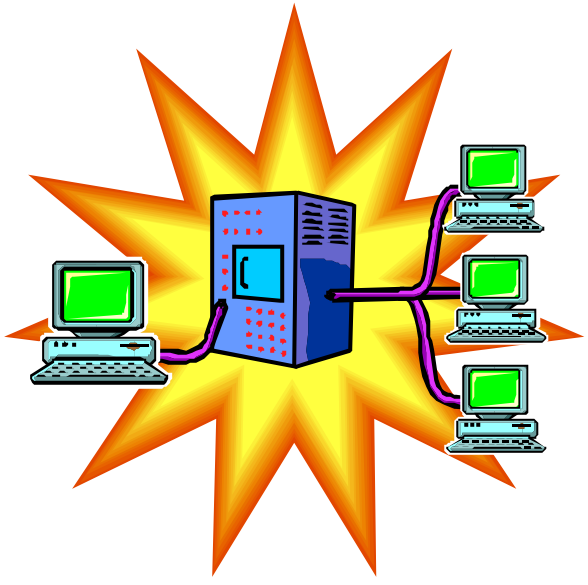
2. Personal libraries with unlimited storage capacity

3. Selection of personal library content based on:
   a) A hybrid information retrieval strategy that combines full-text queries with typed queries; and
   b) A flexible collection and metadata management classification schema

4. Personal library content sharing

❽State of Research

- Narrowing scope to ***storage scalability*** (✓, ✘, ✘)
  - ✘ communication services for library content sharing (VI)
- We are now pursuing a digital object store for server-side personal libraries (I) with:
  - flexible collection and metadata management (II)
  - full-text and typed selection of content (II) and
  - unlimited storage capacity (V)
- i.e. distributed data stores instead of distributed digital object stores



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Thanks for your attention!

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