

Building and Applying Digital Libraries

(Part 1)

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Building and Applying Digital Libraries **2**

- **0. Overview**
- **1. Introduction to Digital Libraries**
- **2. Key Requirements**
- **3. Future Directions**
- **4. Recommendations**

To conserve presentation time, please review slides in Overview section before session

Overview

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- **Instructor background**
- **General Plan for Course**
- **Specific aspects**

Background

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- **1978 --> 1985: ZOG Project, Carnegie Mellon University**
- **1981 --> 1996: Knowledge Systems**
- **1988 --> 1989: ACM Hypertext on Hypertext (KMS version)**
- **1988 --> 1992: Dexter Group**
- **1990 --> 1993: SIGLINK Chair**
- **1990 --> 1996: Editor, ACM Hypertext Compendium**
- **1994 --> 1996: PetaPlex Project (US Intelligence Community)**
- **But most important is experience from using hypertext**

- **Ten year project: 1975-1985**
 - **Funded by Office of Naval Research**
- **General-purpose research on human-computer interaction**
 - **Newell et al**
- **ZOG: Large-scale, rapid-response menu-selection system**
- **Major application:**
 - **ZOG-VINSON Project: 1980-1985**

- **Spun out of Carnegie-Mellon University in 1981**
- **Goal: develop commercial follow-on to ZOG**
- **Purpose: general-purpose enterprise-wide management of knowledge (esp. collaboration)**
- **Focus: Networked workstations**
 - **(e.g., Sun, HP, DEC)**
- **Product: KMS[®] (Knowledge Management System[®])**
- **Current efforts: Applying hypermedia technology to task of constructing large-scale digital libraries**

- **ACM Project to explore Hypertext Publishing**
- **Task: to represent one issue of CACM (July88)**
 - 6 articles from HT87 + keynote + guest editor piece
- **Three systems chosen**
 - Hypercard
 - HyperTIES
 - KMS
- **Lessons learned (Panel HT89)**

- **Informal group of researchers from academe and industry**
- **Started meetings in 1988**
- **--> Dexter Reference Model**
 - The Dexter Hypertext Reference Model Frank Halasz, Xerox PARC Mayer Schwartz, Tektronix Labs
- **Good reference on the Dexter Model is the Feb 94 issue of Communications of the ACM.**
 - Diagram of Dexter Model
- **--> Responsible for organizing**
 - Hypertext '89
 - Hypertext '91
 - SIGLINK

- **ACM Special Interest Group on Hypertext and Hypermedia**
- **Founded in 1990**
- **Approximately 1200 members**
- **Upcoming events:**
 - **Hypertext '97 (Southampton, UK)**
 - **Digital Libraries '97 (where??)**
- **Please join!**

ACM Hypertext Compendium

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- **Hypertext Database on field of Hypertext**
- **Published by ACM Press**
- **First Edition: ~130 articles**
 - **Bush, V --> ECHT '90**
- **Developed by Knowledge Workshop under contract to ACM**
 - **(Examples from Compendium later in course)**
- **Second Edition in progress (triple size)**
 - **HT91**
 - **ECHT '92**
 - **HT93**
 - **Major works of Engelbart et al**
 - **Major works of Intermedia Project**

- **Goal:**
 - Develop architecture for massive-scale digital libraries
- **Objectives:**
 - Capacity: 20 Petabytes on-line
 - Response over Internet: < 1 second for random URN
 - Throughput: 30 million web pages per second
- **Approach**
- **Status**

- **Massively-Parallel Architecture**
 - internetworks 1 million 20-Gb "SmartDisks"
- **Content: hypermedia-structured**
- **"Supercompression" --> high compression level**
- **"DNE" protocol --> single round trip packet**
- **"Knowledge File System" --> single disk seek**
- **Proxy on client-side**
 - to allow use of existing browsers
- **Current prototype based on KMS**

- DNE single round-trip of packets works well
- Average internet response: .5 seconds
- Can construct 9Gb "SmartDisk" under \$2000
- Constructing 1 billion web-page database

But most important is experience from using hypermedia

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- Active hypermedia user
- Using hypermedia on daily basis for 18 years
 - Do virtually everything within HM environment
- ~200,000 nodes in KSI corporate database
- --> source of most of my knowledge about hypermedia

Hypermedia as foundation for 'corporate memory'

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- Articles
- Budgets
- Drawings/Diagrams/Tables
- Email
- Financial statements
- Forms
- Letters
- On-line documents
- Software Programs
- Proposals
- Slides
- Training testing

General Plan for course

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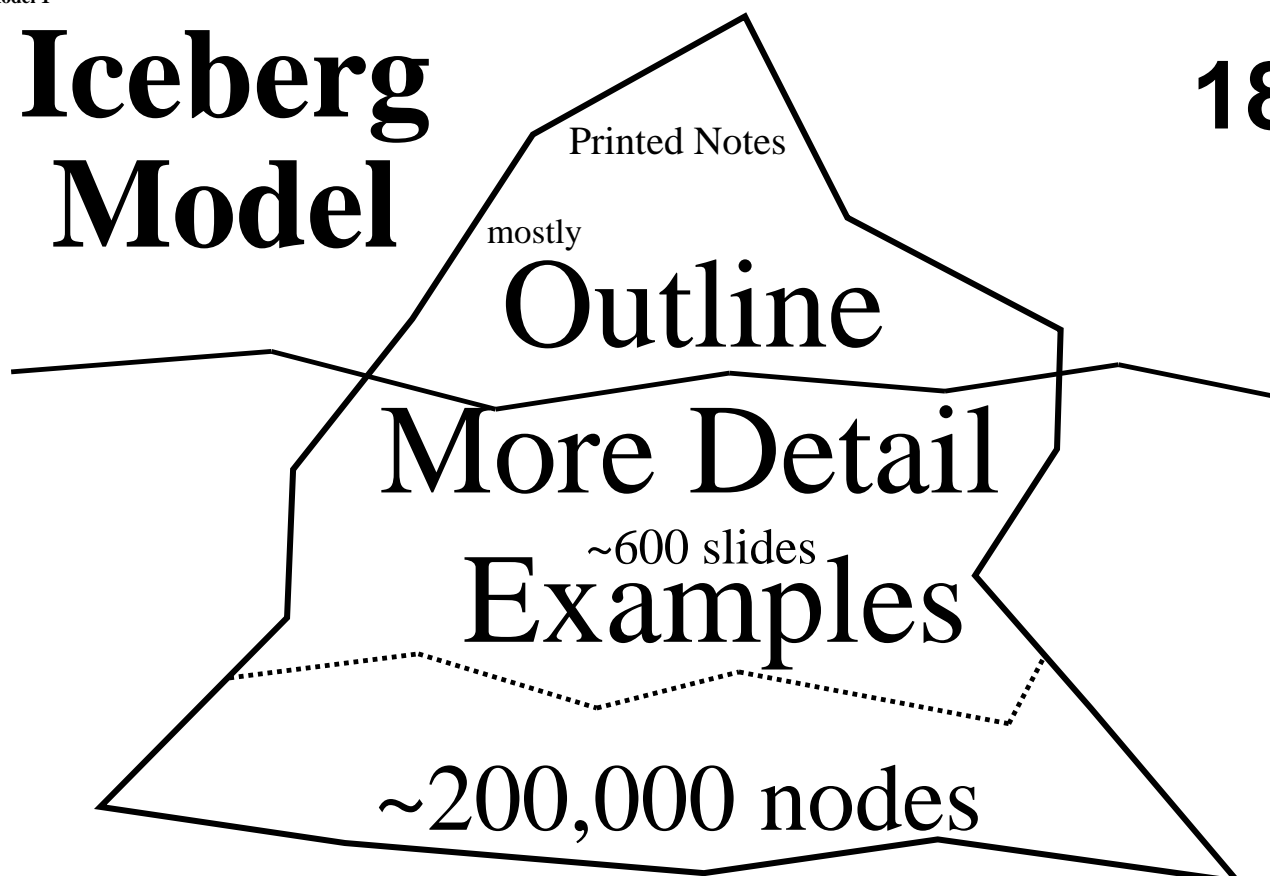
- Issue oriented
- Organize issues by useful categories
- Help build a conceptual framework
- Identify positions on issues
- Identify tradeoffs
- Recommendation(s) about each issue
- Generate discussion about issues

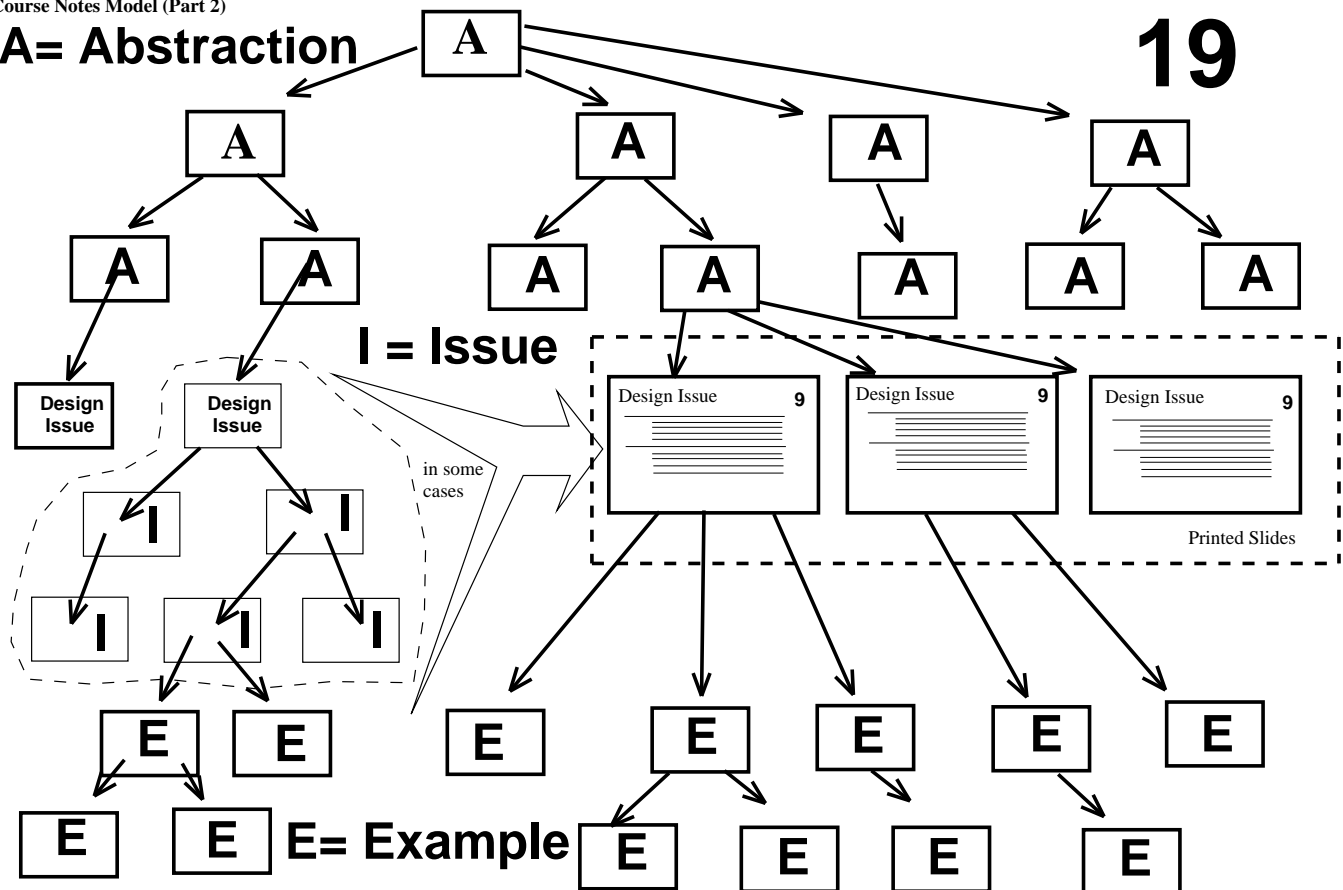
- **Organization of course notes**
 - **Model 1 (printout)**
 - **Model 2 (printout)**
- **Start slow, speed up**
- **Start talking, shift to more discussion**
 - **Use slides more as scaffolding to talk about what really interests us**
- **Rhetorical conventions for slides**
 - **Hollow bullet --> expanded below in slides**
 - **Solid bullet: --> no further expansion in slides**
 - **Red solid bullet (on-line): not in slides, but may show**
 - **No slide number --> a slide not in handout**

Model 1

Iceberg Model

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A = Abstraction**19**

Introduction to Digital Libraries

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- **Concepts and Practices**
- **Relevant Technologies**
- **Existing projects**
- **Existing frameworks**
- **What is different?**

- **What are digital libraries?**
 - Any remote, any size "database"?
- **What's outside the scope?**
 - Traditional Databases?, WWW?
 - Networking? CSCW?
 - Where are the boundaries of digital libraries?
- **Types of Digital Libraries**
- **Central Issue: Digital Library Architectures**
 - What tradeoffs are appropriate to best meet all expectations for digital libraries?

- **Private and Public**
- **Commercial and Non-commercial**
- **Personal and Corporate**
- **Intra-Organizational and Inter-organizational**
- **National (France, Britain, Singapore)**
- **--> Central Issue:**
 - In what ways are these different that lead to different design decision?
 - What factors are different about these types, that suggests need for different approaches?

- **Library and Information Science**
- **Database systems**
- **Information retrieval**
 - Indexing, ...
- **Hypertext/Hypermedia/Multimedia**
- **Human-Computer Interaction**
- **Artificial intelligence**
 - Expert Systems, Natural Language Processing
- **Storage systems**
- **Networking systems**
- **Image Processing**
- **Compression schemes**

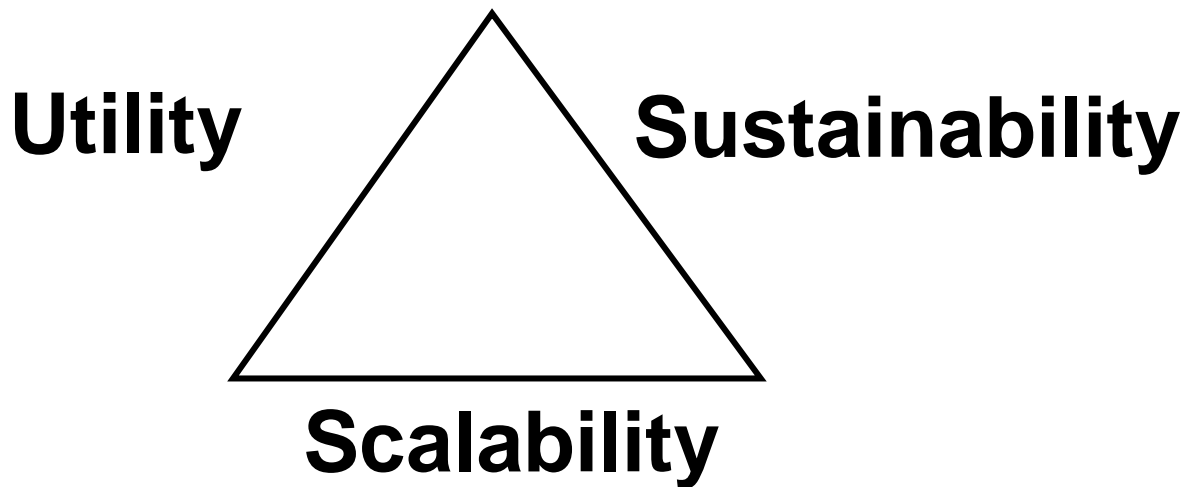
Existing projects (on the rise!)

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XYZ **Mercury** **Dissertations** XYZ **JANUS** XYZ
Handle System
XYZ **TULIP** **QUEST**
Envision **RightPages** XYZ
Gutenberg Project
ELVYN **NSF/ARPA DL Initiative** **CS Tech Reports**
XYZ **CORE** **NASA Mission to Planet Earth** **ARPA BAA** XYZ XYZ
FreeLore Project **CoLib Project** XYZ **Gutenberg Project**
ACM 'Electronic Community' XYZ **PetaPlex Project**
IBM Global Digital Library XYZ
Project Athena **Library of Congress** XYZ
XYZ **Univ Michigan Digital Library** XYZ
XYZ

- **Not much to date!**
 - Exception: Gladney et al.
- **Part of the purpose of this course is to reflect on what should be in useful frameworks**
 - **Why are frameworks useful**
- **Starting points**
 - Key requirements
 - Architecture
 - Activity-based
- **Example 'key requirements' framework**

- **Provide a way to conceptualize field**
- **Provide a way to organize knowledge**
- **Provide a common frame of reference that facilitates communication**
- **Help compare alternate approaches**
- **Help make design decisions**
- **Help make make/buy decisions**
- **Help promote interoperability**



What is same/different

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- From existing libraries
- From other aspects of electronic publishing
- For authors
- For users
- But should also strive to identify and preserve what is the same as traditional libraries
 - Universal access?
 - Sense of organization
 - Sense of discipline
 - Better resources than individuals can afford
 - Completeness

What is different from existing libraries? 29

- **More users, More contexts**
 - Forever open, always 'close by'
- **Economics change significantly**
 - Scalability issues very different
- **More possibilities for organizing content**
 - Multiple indexes and views, multiple search engines
- **More possibilities for integrating with task environments**
 - Access reference within context of constructing knowledge artifact
 - Link directly to references
 - Link directly to components (e.g. for reuse)
 - Copy components into another context

From other aspects of electronic publishing 30

- **Scale**
 - Not just small number of documents
- **Interlinking**
 - Widespread, inter-document linking
 - Within-DocA --> Within-DocB
- **Indexing**
 - Indexing across many documents/artifacts
- **Range of size of objects**
 - Poem --> Essay --> Article --> Book --> Encyclopedia
 - Image --> Video
 - Code: Statement --> Routine --> Module --> Library
- **Greater usability problems**
 - Some induced by scale
 - Some induced by heterogeneity

- **Scale of what is considered publishable/valuable**
 - (Paragraphs and Diagrams) vs (Articles and Books)
- **Collaboration with co-authors**
 - Co-authors can work on same version
 - Rise of 'Sou-authors' (authors who prepare for others)
- **Maintenance of documents (versus frozen)**
 - Authors more like editors of series
- **Rhetorical freedom/limitations for Diagrams**
 - - Less resolution for diagrams
 - + Color more available
 - + Use of animation
 - + Use of current data
- **'Dual document' considerations**
 - What to do if publishing paper (or other forms) as well

- **Access material previously could not afford to access**
- **Ability to dive directly into depths of documents**
- **Annotation/collaboration**
- **Note taking (with links to references)**
- **Searching**
- **Re-use (under fair use)**
 - Clipping of portion of another artifact
 - Linked quotes
 - Reference by linking
 - Overlays

- **Perspectives**
 - **1. Utility**
 - **2. Scalability**
 - **3. Sustainability**

Utility = Usefulness + Useability

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- **Centrality of task environment**
- **Usefulness**
 - **Framework-2: User-Task-Info-Cap**
 - **Nature of the Content**
 - (Media, Data models)

Useability

- **Capabilities**
- **User interface design**
- **User studies**

- **More than any other factor, the nature of the task is key to good design**
 - "Know the user" is too indirect
 - "Know the task" more appropriate
- **Best way to understand task is to personally do task (repeatedly)**
 - People you interact with may themselves not be true end-users
 - Incremental feedback better than quantum leaps
 - Important to understand differences among tasks and how needs differ
- **Particularly difficult is relationship to outer task environment**
 - E.g., Computing environment often most binding constraint

"Know the task" more appropriate

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- **If you look at most physical tools (e.g., hand tools)**
 - their design is mostly a function of the task
- **There is surprising little about their design that is human factors inspired!**
- **The task environment is a given and is not as flexible at higher levels**
- **The tool is often very specific to the task**
 - for simplicity, ruggedness, effectiveness, etc
 - thus usually not flexible
 - exception: swiss army knife
- **But humans EXTRAORDINARILY flexible and adaptable**
- **Tool designers should exploit this flexibility**

- **What forms/organizations of information do people want/need?**
 - Depends on task environment!
 - Some answers are known
 - but many issues still are empirical questions yet to be answered
- **Ways to add value**
- **A Fundamental Design Tradeoff**
 - All things to all people
 - Some things to some people
- **Recommendation:**
 - Work bottom-up -- first be some things to some users
 - E.g., programmers (as a particular class)

Principal Task Environments: "3 E's"

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- **Entertainment**
- **Education**
- **Enablement**
 - Tools that enable users to perform tasks
 - Faster, better, cheaper,....

- Accessibility/Scale/Authentication
- Completeness
- Indexing/Cataloging
- Chunking/Organizing/Structuring
- Interlinking/Cross-referencing/Naming
- Review/Critique
- Abstraction/Overviews/Condensations/Surveys
- Import/Exporting/Conversion
- Discovery/Search/Awareness services
- Integration with other tools
- Integration across libraries
- --> Improve productivity of user

Framework: User-Task-Info-Capability 40

- Purpose of framework
 - flush out needed information and capabilities
- U-T-I-C Diagram
- Types of USERS
- Types of TASKS
- Types of INFORMATION (content)
- Types of DL capabilities to process information
- Diagram: subtyping of each level of framework
- Impact of Organization

Types of Users (roles)

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- **Administrators**
- **Engineers**
- **Investors**
- **Managers**
- **Programmers**
- **Scholars**
- **Scientists**
- **Secretaries**
- **Students**
- **Teachers**

**But note: people often
perform multiple roles
same/different times
same/different tasks**

Also as members of teams

Types of tasks

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- **Communicating**
- **Deciding**
- **Designing**
- **Evaluating (Grade, Critique, ...)**
- **Fact finding**
- **Learning**
- **Modelling**
- **Planning**
- **Presenting**
- **Researching**
- **Writing/Publishing**

Types of information

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Editorials Diagrams Calendars Lists
Memos Images News Regulations Data
Policies Invoices Formulae Predictions
Photos Schedules Speech Letters
Trends Maps Procedures Essays
Drawings Code Clips Events Scripts
Hints Patents Orders Forms
Instructions Directories Stories
Laws Tables Plans Symbols

Types of capabilities to process information

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- Authoring
- Citing
- Clipping
- Converting
- Displaying
- Exporting
- Formatting
- Linking following/Link creation
- Searching
- Sending
- Transforming
- Notetaking/Notemaking

- **Media**
 - Text
 - Graphics
 - Images
 - Sound
 - Video
- **Data models**
 - Linear
 - Tabular
 - Hierarchical
 - Network
 - Relational, Object oriented, Hypertextual ...
 - Hybrids

Data Model is more important than the media!

- **Access Methods**
- **Processing content/Executable content**
- **Integration with others systems/tools**
- **Support for Specific Applications/User Communities**

- **1. Navigation**
 - Browsing
 - Problems
 - Approaches
- **2. Search and query**
 - Keyword
 - Full-text
 - Concept search
 - Structure search

- Browsing
- Problems
 - Disorientation
 - Cognitive Overload
- Approaches
 - How can system address disorientation?
 - How can system address cognitive overload?

- **Difficulties**
 - Not knowing where one is
 - Not knowing what surrounding terrain is like
 - Not knowing where info sought is located
 - Not knowing how got to current location
- **However**
 - "Lost in Hyperspace" is often over-dramatized
 - Solutions proposed (e.g., overviews) don't address multiple facets of problem

- **Description**
- **Examples**

Description of Cognitive Overload

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- **User confused about his/her objectives,...**
- **Stress of difficulty of using system overloading user and distracting from task**
- **Whereas disorientation is confusion about the hypertext itself**

Examples of Cognitive Overload

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- **Not sure how 'current node' relates to user's task**
- **Not sure what links to follow**
 - **Relative to current task**
- **Not sure how to structure latest thought**
 - **Need to just get it out somehow versus extensive interrupt)**
 - **Example: navigating to 'safe harbor' for idea, but then forgetting idea 'enroute'**
- **Logistics of using system saps user's task orientation**

How can system address disorientation?

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- What can cause disorientation?
- Problems that may result
- How can it be reduced?
 - Traditional answer: Overviews, but ...
 - Traditional answer: Search and Query
 - Traditional answer: Graphical cues
 - Traditional answer: Bookmarks
 - Another approach: Aliases

How can system address cognitive overload?

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- Keep data model very simple
- Make link anchors as informative as practical ("rhetoric of departure" --- Landow)
- Provide mechanisms for 'lazy organizing'
- Facilate 'Switchyards'

- **Keyword**
 - Known to be suboptimal (but scalable)
- **Full-text**
 - Scalability to DL levels is open question
 - Good opportunity to think 'tradeoffs'
- **Concept search**
 - Use of terms other than ones provided
- **Structure search**
 - Part navigation to sub-scope, then search 'within'
 - Surprisingly useful type of search!

Processing/Executable content (Agents)56

- **Searching, Transforming, Executing, ...**
- **Document composition**
- **Document printing**
- **Authoring assistance**

- **Very important**
 - Source of considerable 'task leverage'
 - This is where DL's might derive most of their value-added
- **Types of integration**
 - Programs
 - Databases
 - Other DL's
 - Other types of DL's (personal, organizational, public)
- **Means of integration**
 - Import/Exporting (shared formats)
 - Reading shared store
 - Dynamic exchange (real time)

Support for Specific Applications/User Communities ("task environments")

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- **Key theme: What needs are different enough to have design implications?**
 - 1. Research and development
 - 2. Education and Training
 - 3. Business and Government
- **4. Collaborative Work**

- Literature search/read/notetaking
- Issue analysis
 - Need for 'Structured' Discussion groups
- Modelling
- Computer-supported cooperative work
 - High need to co-author documents
 - Interaction with peer 'concurrent engineers'
- Publishing

- Testing
 - Course examinations
 - On-line self-assessment
- Distance learning
- Self-paced learning
- Curriculum enrichment
 - Cross-course linking
- Large-screen presentation
- Stepping stone to other communities
 - --> Need to experience on-line tools and techniques of those communities

- **Access to conformance documents (regs, policies, standards)**
- **Communication**
 - Internal
 - External (e.g., marketing collateral, Announcements)
- **Document development**
 - Authoring/Co-authoring
 - Dissemination
 - Use as templates
 - Use for submission
- **Evaluation (of proposals)**
- **Record keeping**

- **Types of interaction**
- **Amount of use affects importance of efficiency**
- **User-system cycle time**
- **Underappreciated role of User/Org Conventions**
- **Relationship to data model**
- **Recommendations:**
 - Bias system toward rapid system response
 - Bias system to support rapid interpretation
 - Bias system to support rapid user response

- **Command**
- **Menu**
- **Direct manipulation**
- **Hybrids**
 - **May be more natural even if not consistent**

- **What makes a difference?**
 - **System response time**
 - **User interface directness**
 - **Simplicity of conceptual data model**
 - **Fewer more homogeneous node layouts**
 - **Node and object Schemas**
- **Why important?**
 - **Makes significant difference in style and productivity**
 - **Products developed are not the same as otherwise would be (with less-facile systems)**

Underappreciated role of Conventions (versus features)

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- **Norms users decided for themselves**
 - Not enforced by system
- **Important roles for Conventions**
 - Allows more exploration within specific task environments
 - Conventions substitute for 'Designer Knows Best'
 - Good pre-test of future functionality

Relationship to data model

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- **Data Model is Heart of User Interface Design**
- **Constructs and their nature determine possibilities**
 - Operands * Operators --> sets stage for User Interface
 - Provides many issues concerning defaults

- Instrumental for improving usability
- What we know about existing libraries?
 - Electronic and non-electronic
- What we know from hypertext/hypermedia studies?
- What do we know about use of information retrieval systems?
- What would we like to know and how to incorporate in design cycle
 - Embedded instrumentation

- 1. Why is scalability important?
- 2. Architecture
- 3. 'Stocking the shelves'
- 4. Price/Performance
- 5. Security and Integrity

Why is scalability important?

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- **Small scale libraries less interesting, less complete, less interlinking**
- **Permits economies of scale**
 - Construction
 - Maintenance
- **Enables simpler fee mechanisms**
 - E.g., subscription fees
- **But large scale systems face technological challenges**
 - Response time
 - Cost of construction and maintenance

Architecture

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- **1. Hardware**
- **2. Software**
- **3. Networking**

--> Architecture can determine overall price/performance of the system

--> Need to avoid drowning in possibilities!

- 1. OCR
- 2. Document analysis
- 3. Conversion
 - Especially structuring for on-line access
- 4. Formats -- SGML, HTML, HyTime,

- 1. Response time
 - Bandwidth conservation
 - Load-balancing
- 2. Storage efficiency
 - Hypothesis: \$50 per Gb is a key threshold for large-scale digital libraries
 - At this point other cost factors dominate (e.g., systems administration)

- **More functionality more problems**
- **1. Permissions**
- **2. Concurrency control**
- **3. Annotation**

- **Costs of construction and operation**
- **Pricing**
- **Fee mechanisms**
- **Who actually pays?**
- **Incentives to all stakeholders**
- **Intellectual Property Issues**
- **Relationships to other communication mechanisms**
- **Competition**

- **Acquiring rights**
- **Processing raw material**
- **Editorial effort**
 - **May be the dominant cost!**
- **Maintenance of material**
- **Maintenance of infrastructure**
- **Archiving**

- **Who pays how much for what?**
 - **Need for two orders-of-magnitude reduction in price**
 - **Otherwise we remain 'Knowledge Rich, Access Poor'**
 - **Otherwise we remain 'Access Rich, Knowledge Poor'**
- **Topic of active discussion on/for Internet**
 - **Internet-wide**
 - **Electronic Communities (e.g., ACM Electronic Community)**

- **Usage-based vs. Flat Fee Subscriptions**
- **Priority-based scheme could be way to deal with congestion**
- **How do these impact on the user?**
 - Usage-based schemes destructive of productivity
 - Organizations prefer peace of mind from flat-fees
- **How do these impact on the library?**
 - Assuming expenses < revenues
- **Recommendation: Strive at all costs for flat fees!**

Who actually pays?

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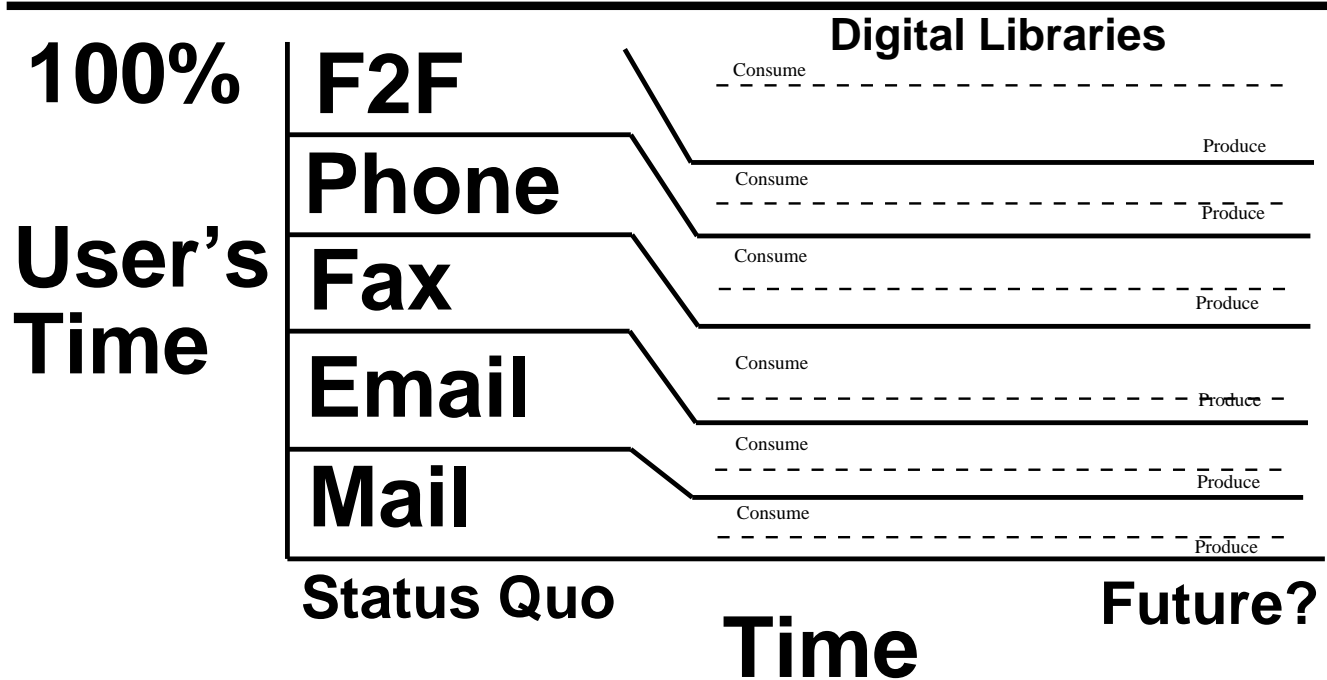
- **Information provider?**
 - Perhaps for marketing 'collateral'
- **User?**
- **User's patron?**
 - Parent
 - Dean
 - Employer
- **--> Perhaps User's patron will likely be most important decision maker to convince**

-
- How do we motivate all parties to collaborate?
 - Authors
 - Editors
 - Publishers
 - Educators
 - Librarians
 - Subscriber Users/User Patrons
 - Technologists
 - Vendors
 - --> Need 'We-all-need-each-other' type of Win-Win arrangement

-
- Rights
 - Electronic version blur boundaries (Is it a book or movie?)
 - Fair Use
 - Where are new boundaries?
 - Derivative works, colorization problems, Clipping, Linking to/from
 - Enforcement mechanisms
 - Authorization
 - Authentication (e.g., Kerberos)
 - Contracts

- How does digital libraries displace/supplement other channels?
 - Paper
 - Email
 - Fax
 - Phone
 - Existing libraries
- Market share of user's time?

Market share of user's time? (and productive use of user's time) 82



Key question is how each enables productivity!

- **Paper**
- **Culture (inertia, perceived threats)**
- **Competing designs/paradigms (to traditional commercialization)**
 - Free browsers
 - Free content (e.g., promotional materials)
 - Free authoring (vanity publishing)
- **Cost (has to be significant reduction)**
 - To be interesting
 - To overcome inertia
 - To make a significant difference

- **Need to develop practical theoretical framework**
 - Otherwise we get 'synergy-free' trajectory
- **Information 'SuperHypeway'**
- **Problems Digital libraries may face**
- **Potential Pitfalls**
- **Conferences**
- **Specific Initiatives**

- **Some consider Internet de facto "information superhighway"**
 - 30+ million users and growing rapidly
 - Dramatic interest in WWW/Mosaic/Netscape technology
 - But individual users can cause significant problems
- **Others: digital video on demand, ...**
- **Issues proliferating faster than consensus**
 - E.g., Need for (or not) "Universal Access"
- **HTML Extensions now out of control**
 - Multiple groups vying for supremacy

- **Scale problems**
 - Bandwidth congestion
 - Server congestion
- **Sustainability**
 - Not clear how best to recoup costs
- **Location dependence for documents/nodes/links**
- **Cross-platform support**
- **Cross-library support**
- **Fear from existing publishers**

- Bias toward entertainment rather than economic value
- Everyone is an author and no one is an editor
 - Low quality diminishes demand
 - But (nightmare) ease of access could breed complacency with substandard info
- Trying to support too many variations
 - Formats, protocols, views, platforms, rights, fees)
- Usage-based pricing squelching true demand
- Fragmentation into many small libraries with no meaningful integration
- Not making optimal tradeoff for in/out bandwidth
 - Asymmetric bandwidth is acceptable tradeoff

Conferences

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- Feb94: Massive Digital Data Systems Workshop
- Mar94: Digital Library Workshop in San Antonio
- May94 Rutger's Digital Libraries Workshop
- Jun94: On-line Publishing '94
- Jun94: Digital Libraries '94
- Sep94: ECHT '94
- Oct94: Multimedia '94
- Jun95 Digital Libraries '95
- Nov95: Multimedia '94
- 1996: HT96, DL96, and a hundred Internet/WWW conferences

--->
Information Retrieval
Hypertext
Multimedia
Digital Libraries

- **1. NSF Digital Library Initiative**
 - NSF Announcement
- **2. ARPA**
 - ARPA BAA94-28
- **3. US Intelligence Community**
- **4. Universities**
- **5. Publishers**

- **Simplicity is key -- but is incredibly difficult**
 - You must be immovable object
 - successful against irresistible forces
- **Experimentation and incremental development**
 - 'Perpetual Prototyping'
- **Focus first on data model tradeoffs**
 - then user interface
 - then script language
- **Strive for rapid system response**
 - Probably the single most important usability factor
- **Avoid 'premature automation'**
 - Get hands dirty doing tasks manually