Interactive Information Retrieval

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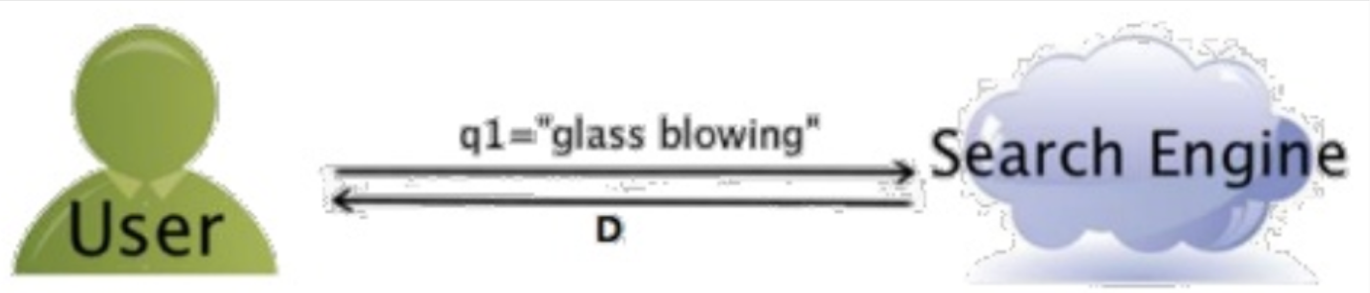
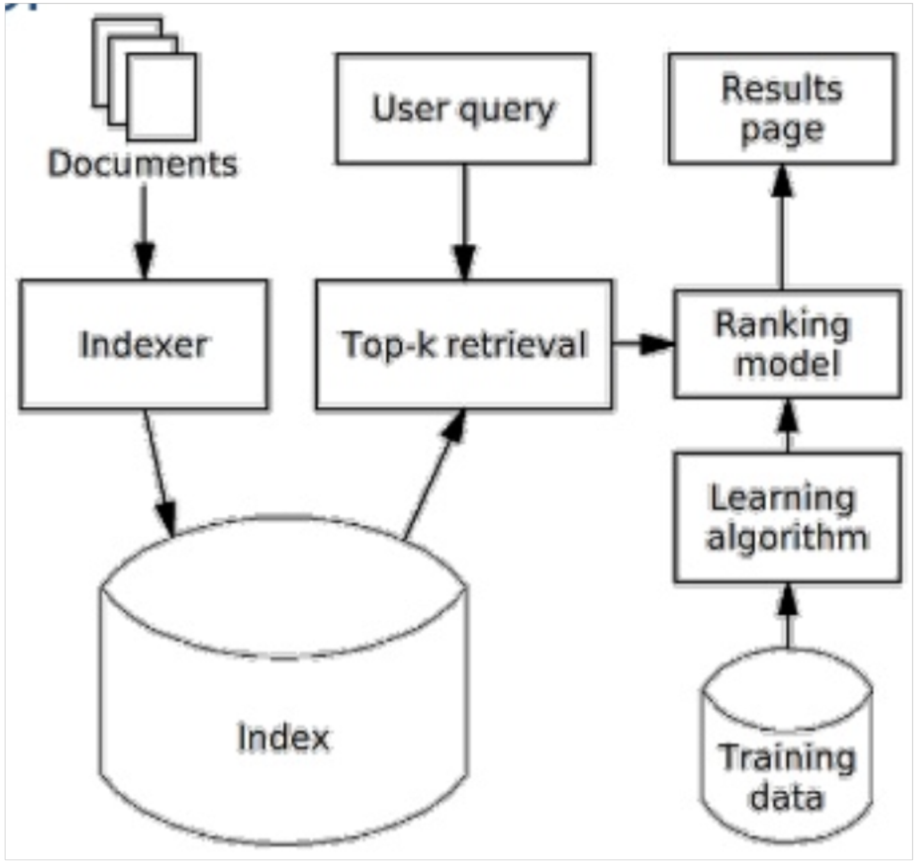
Static Information Retrieval

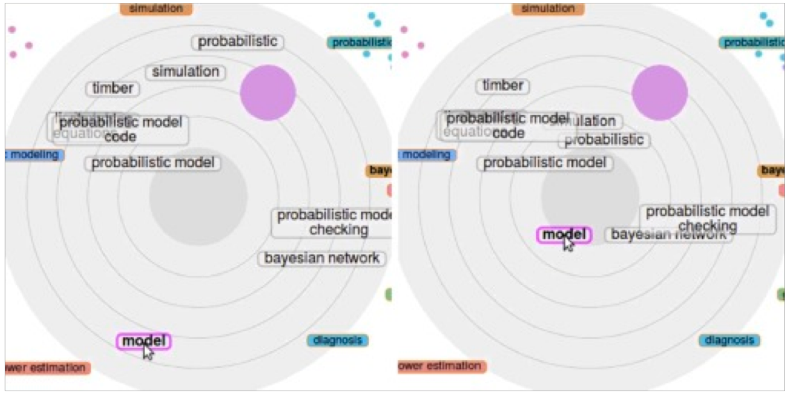
- System does not learn directly from the user
- Parameters updated periodically



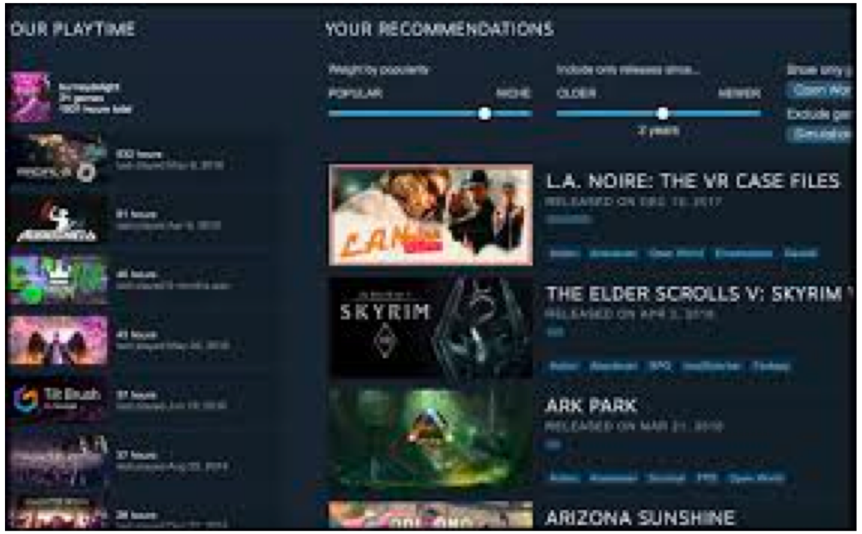


- Aim is to maximize precision and recall
- User's information need is static

Interactive Recommendation

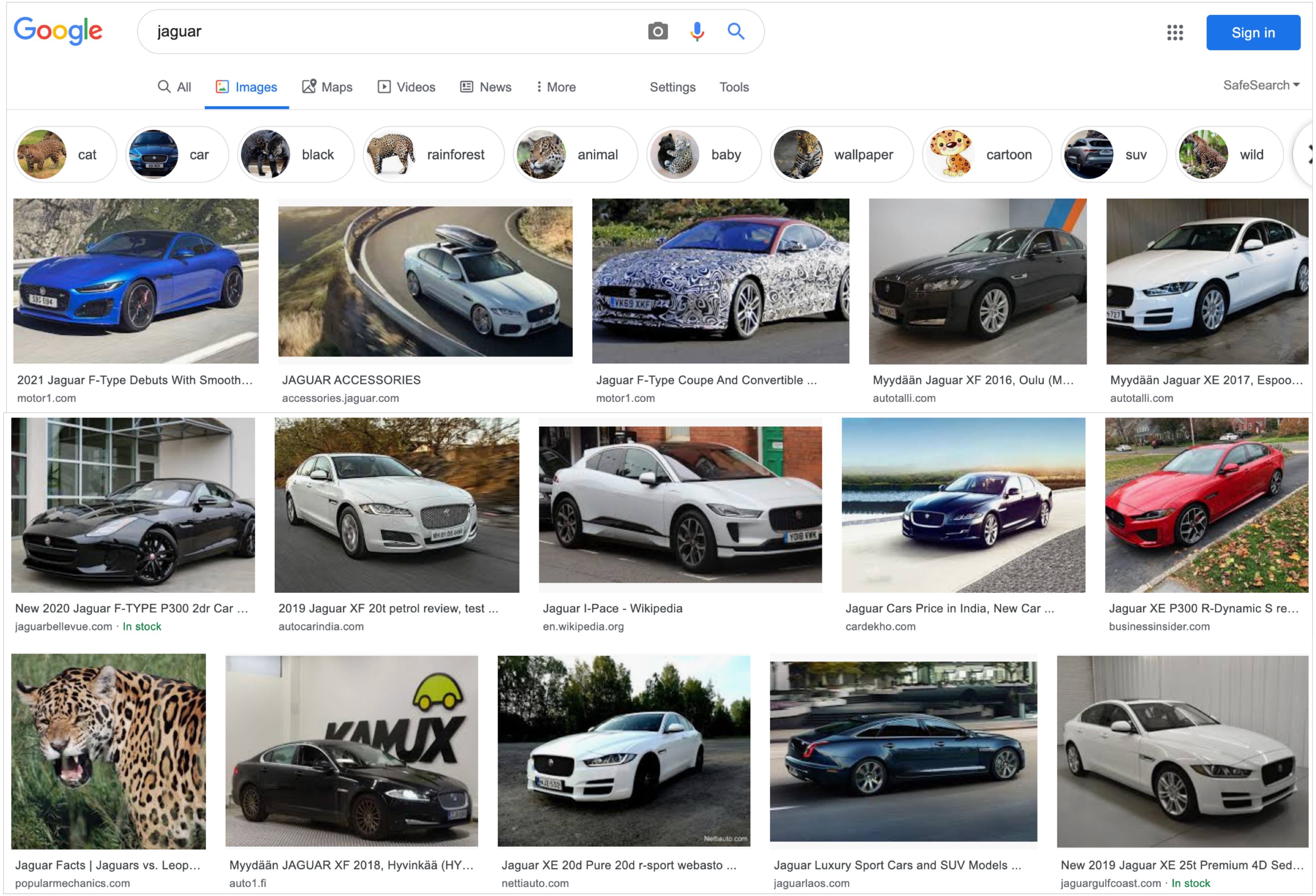


SciNet scientific literature recommendation



Steam Interactive Games Recommendation

- System learns from user feedback in an interactive setting (while the user is engaged with the system)
- Recommendations improve gradually within the interaction session (and beyond)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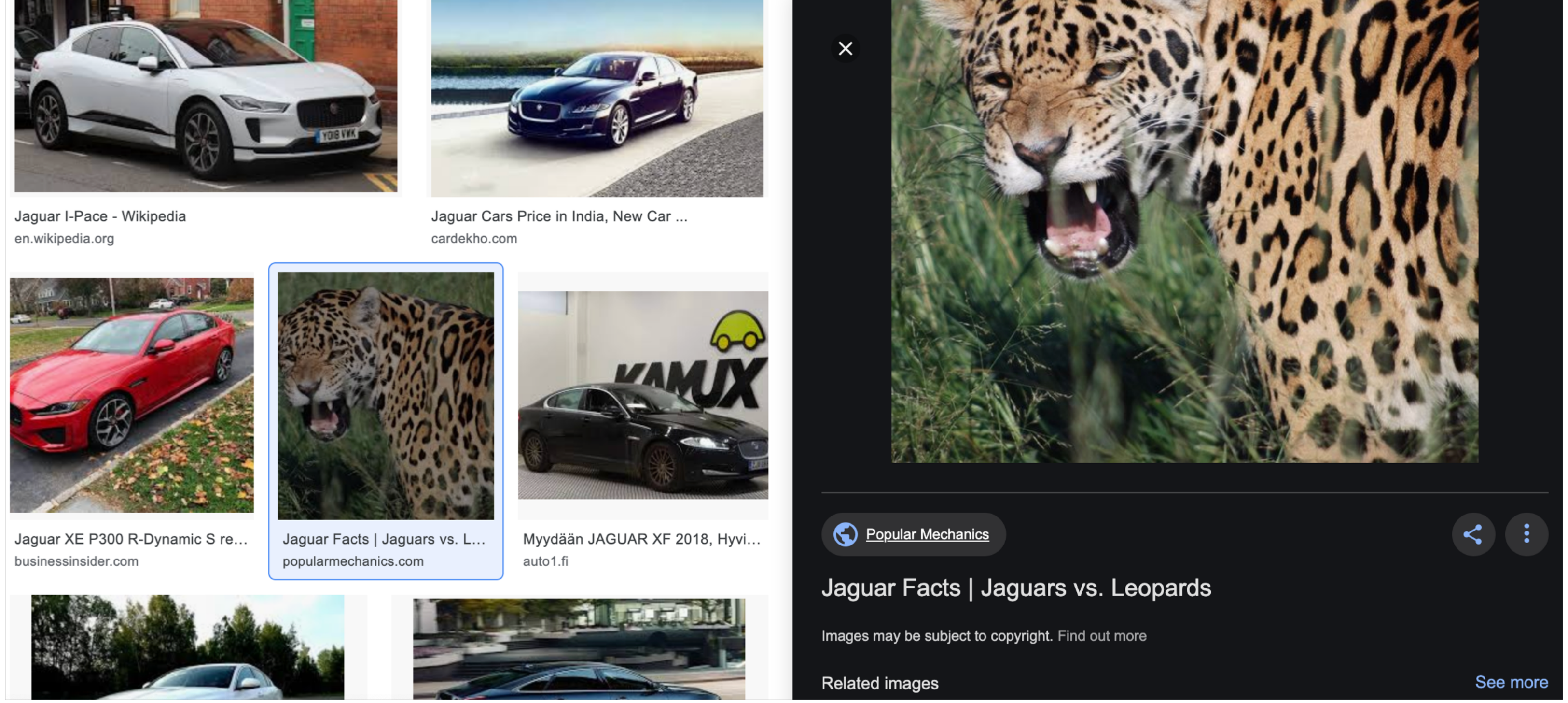
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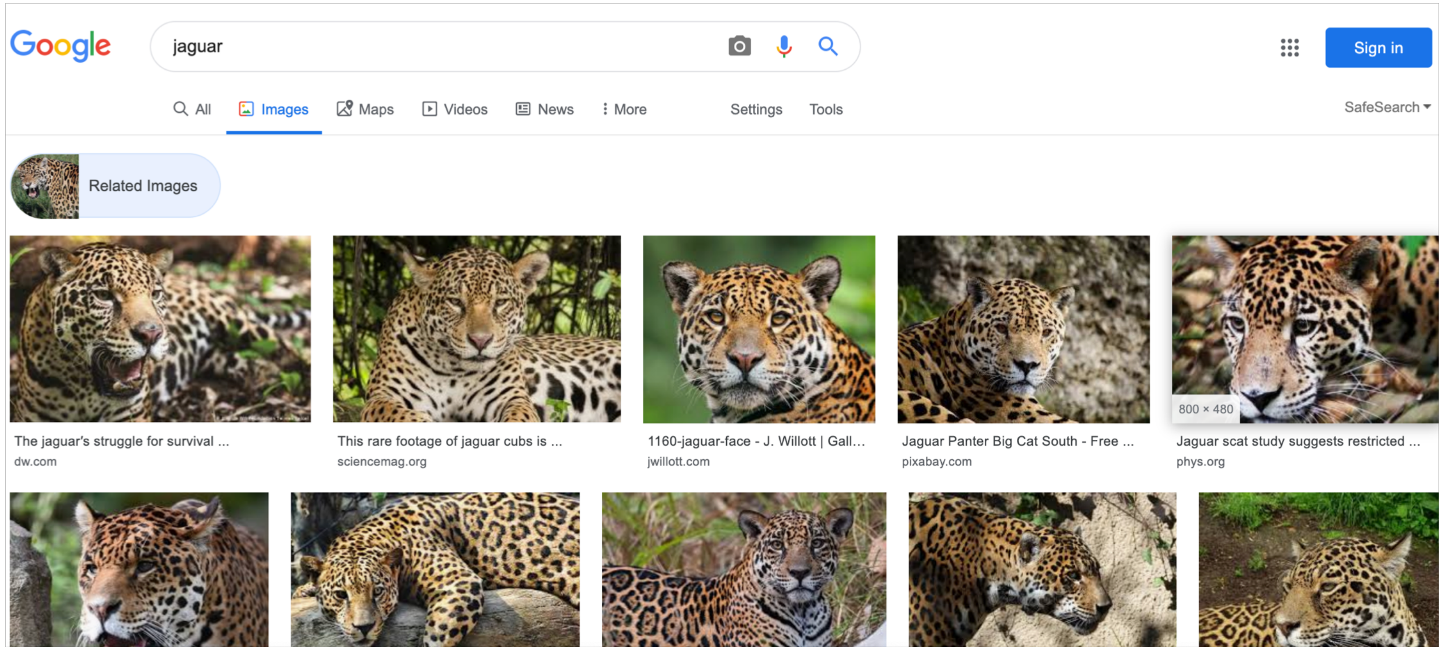
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Human centred approach to Information Retrieval

- Cognitive viewpoint of information retrieval:
  - more focus on user needs and how they search for information
  - matching user side and interaction
- Interactive IR
  - more than simply developing interfaces for searching (Shneiderman, Byrd, & Croft, 1998)
  - knowledge of people's search behavior and search context, including the environmental factors that influence behavior (Fidel & Pejtersen, 2004)
- HCIR (Human Computer Information Retrieval)
  - HCI and IR come from different traditions:
    - HCI places more emphasis on usability
    - IR emphasizes system effectiveness

Interactive Information Retrieval

- Goal: study ***user interaction*** with a search system to learn about the user's ***search intent*** and when they encounter relevant documents
- Taking account of user and their **search context** can improve understanding of the ***search process*** and the user's intent
- A search system that ”knows” this information can improve its performance in retrieving documents that ***satisfy user's needs***
- Awareness of demands imposed on user's ***cognitive processing*** and ***levels of user's knowledge*** can contribute to improvements in system performance.

Interactive Information Retrieval Problems

- IIR research addresses three major problem areas:
  1. Understanding information seeking needs and behaviors;
  2. Developing retrieval systems that respond to information needs and support information seeking behaviors and interactions;
  3. Developing methods and measures to study and evaluate behaviors, interactions and systems.
- Issues
  - Information seeking behavior related information needs and query intent
    - Models of the Information Seeking Process
  - Design of Search User Interfaces and presentation of search results
  - How to evaluate IR systems / Search Quality

Information Seeking Models

- Represent how people search for information in specific environments and how they interact with IRs and/or traditional sources to satisfy information needs
- Models vary based on what researchers investigate:
  - type of user, e.g. novices vs. advanced researchers
  - search environment, e.g. web search vs. online library
  - types of documents/information, e.g. specilised vs. non-specilised literature
  - user’s search goal, e.g. looking for a specific documents vs. general browsing
- Commonality across user information seeking

Models of Information Seeking Behaviour

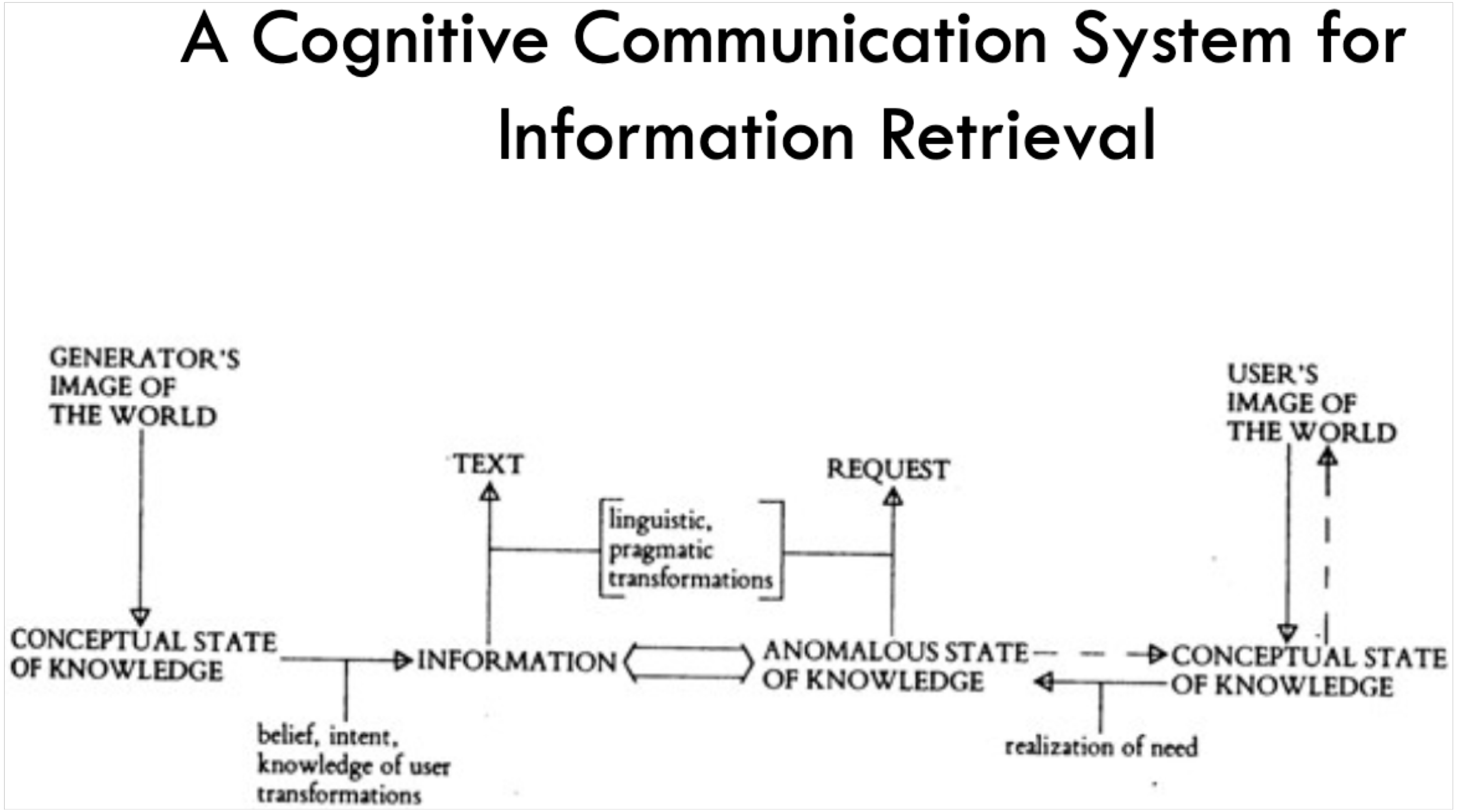
- Belkin’s Anomolous State of Knowledge (ASK)
- Bates’ berrypicking – acts in searching
- Dervin’s sense-making theory – gap, bridge
- Ellis’ Information Seeking Process
- Marchionin’s Information Seeking Model
- Kuhlthau’s information search process
- Ingwersen’s cognitive model
- Wilson’s information-seeking behaviour model
- Saracevic’s model of stratified interaction

Belkin’s Model (1984)

- User’s information need: Anomalous State of Knowledge (ASK)
- Knowledge gap (anomaly) and the need to solve it
- Difficult for user to specify information needs
- Interview to elicit problem statements to determine the user’s ASK
- After ASK determined, formulate query in system’s language
- ASK Definition:

  A recognition by an individual that his/her model of some aspect of the external world and of her/her position in it with respect to some particular situation is insufficient and knowledge is needed to reduce uncertainty

Belkin’s Model



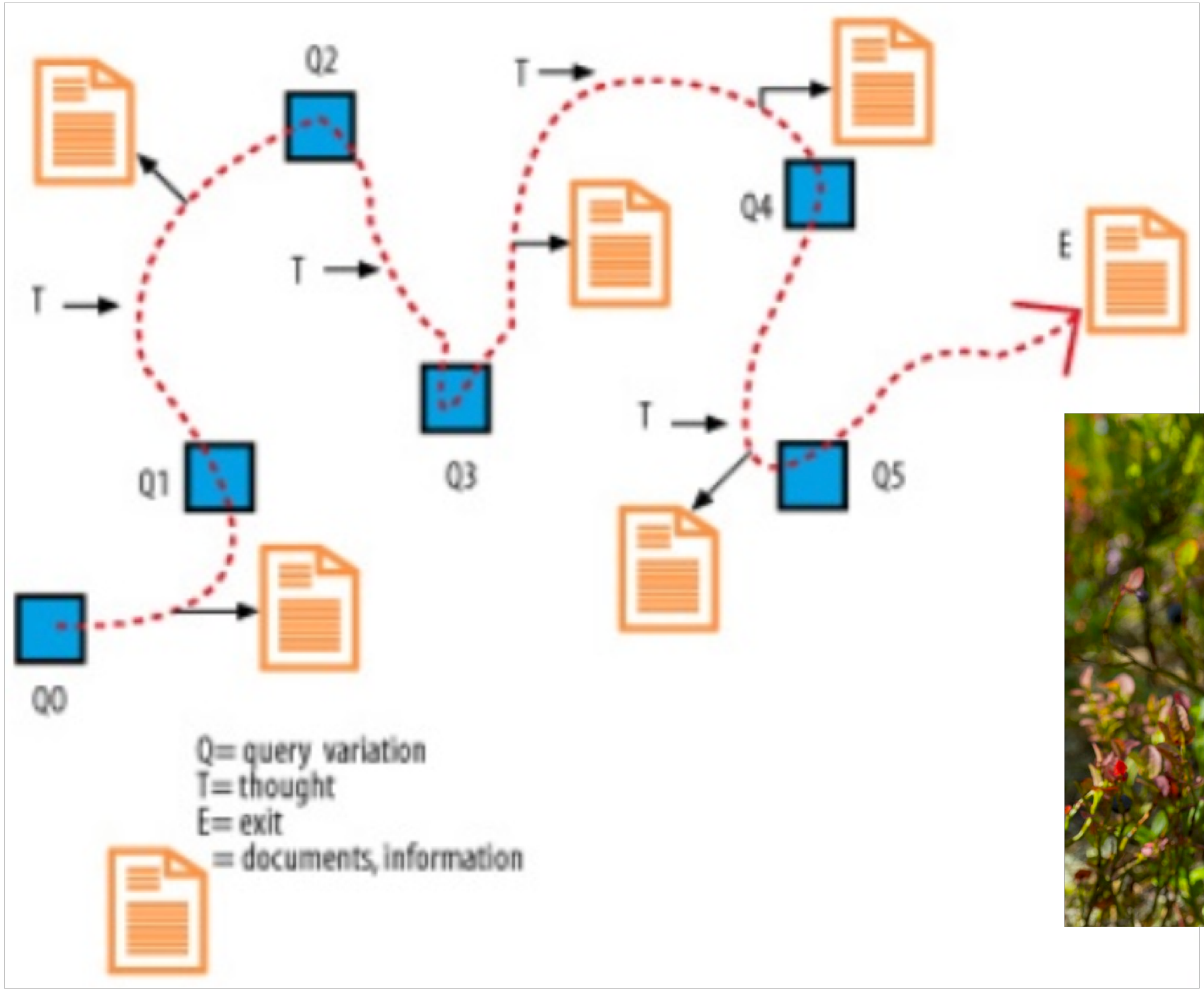
Contributions of ASK

- Reinforced the certainty of the user's needs

- Recognized the iterative nature of information retrieval
  - users return to the IR system repeatedly to satisfy their information needs

- Move towards system design that is user- rather than system-centered (people rather than documents)

Bates' Berrypicking – dynamic not static



Berrypicking model

- Static IR model:
  - The information need remains the same throughout the search session
  - Goal is to produce a perfect set of relevant documents with respect to the query
- Berrypicking model:
  - The query is continually shifting
  - Users may move through a variety of sources
  - New information may yield new ideas and new directions
  - The value of search is in the bits and pieces picked up along the way

Dervin's sense-making theory

SITUATIONS: The time-space contexts at which sense is constructed.

GAPS: The gaps seen as needing bridging, translated in most studies as "information needs" or the questions people have as they construct sense and move through time-space.

USES: The uses to which the individual puts newly created sense, translated in most studies as information helps and hurts.

questioning that can reveal the nature of a problematic situation, the extent to which information serves to bridge the gap of uncertainty, confusion, or whatever, and the nature of the outcomes from the use of information.

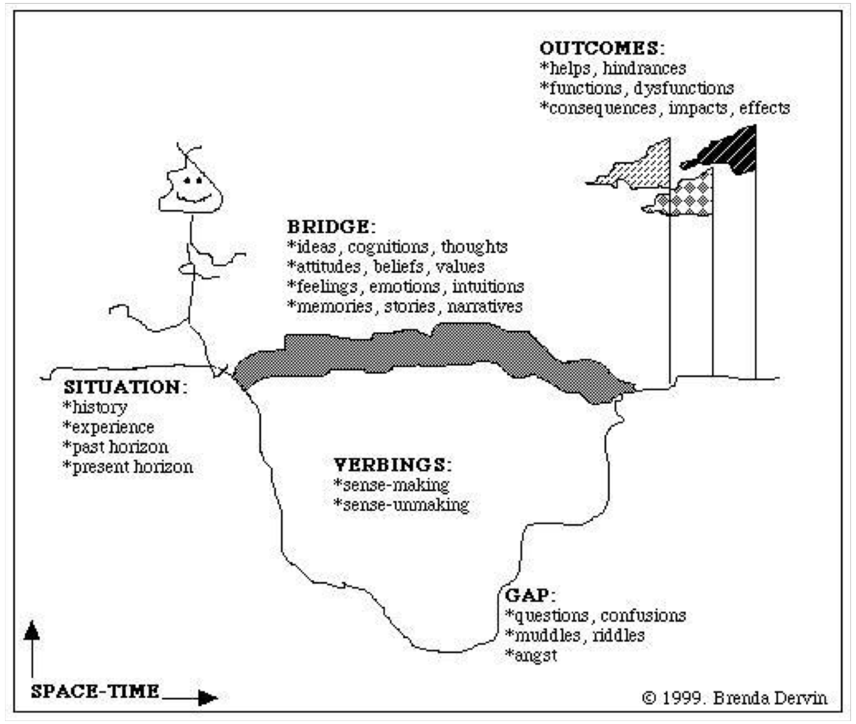
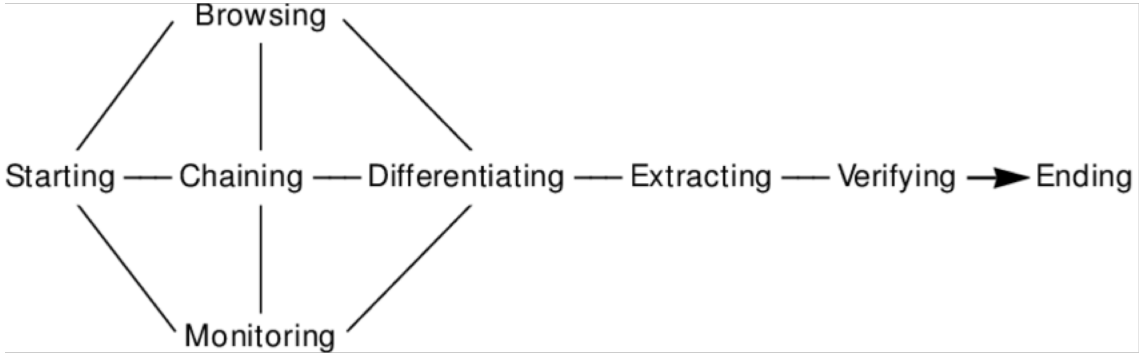


Figure 3: Dervin's 'sense-making'

Ellis' Behavioural Model

David Ellis describes 8 information seeking patterns of social scientists, physical scientists, and engineers in using hypertext (e.g., the Web).



- Starting (Surveying)
- Chaining
- Monitoring
- Browsing
- Differentiating (Distinguishing)
- Filtering
- Extracting
- Verifying
- Ending

Ellis' Behavioural Model (1989)

- ***Starting***: Looking for information in a new area on on a new topic.
- ***Chaining***: Searching by following citation connections between materials.
- ***Differentiating***: Selecting information sources based on their orientation and intended audience.
- ***Monitoring***: The continuous monitoring of developments in a field of study.
- ***Extracting***: Going through a particular source selectively identifying relevant material from that source

Marchionini’s Model

- Problem solving approach to understanding information seeking process in the electronic environment
- Eight processes that may work in parallel:
  - Problem recognition
  - Problem definition
  - Selection of system/source
  - Problem articulation (query formulation)
  - Search execution
  - Examination of results
  - Extraction of desired information
  - Reflection, Iteration, and Stopping of search process

Kuhlthau's Model (1991)

- Six stages in the information search process incorporated in three realms:
  - affective – feelings
  - cognitive - thoughts
  - physical - actions

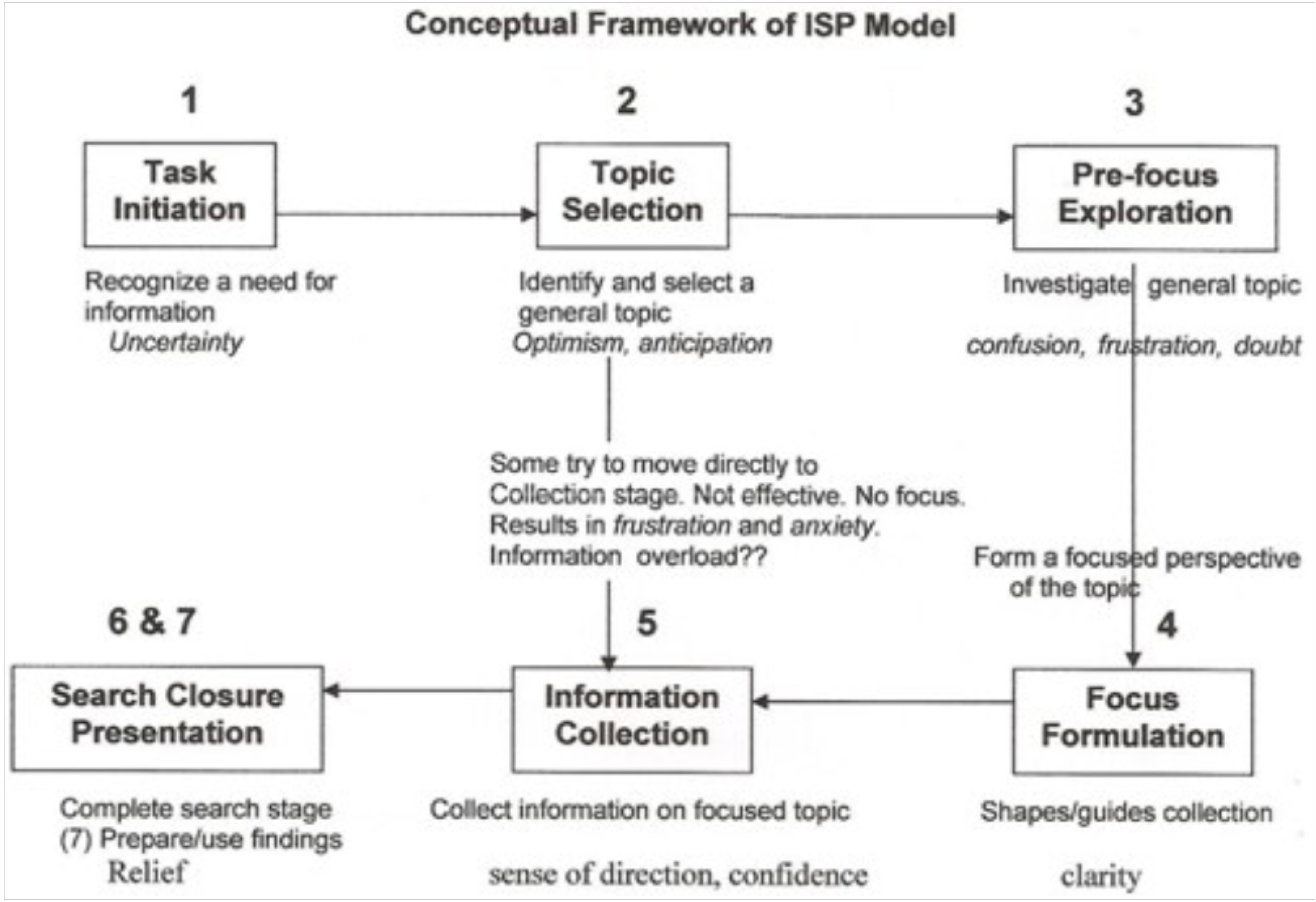
- **initiation** - the first awareness of a lack of knowledge or understanding
- **selection** - identifying the general topic of the approach to be pursued
- **exploration** - investigating information on the general topic, to improve orientation sufficiently to form a focus for resolving the problem
- **formulation** - forming a focus for the information encountered
- **collection** - extends and supports the focus and selects information pertaining specifically to the focus
- **presentation** - completing the search and preparing to present or otherwise use the findings

Kuklthau's Information Search Process

Tasks	Initiation	Selection	Exploration	Formulation	Collection	Presentation
Feelings (affective)	uncertainty	optimism	confusion/ frustration/doubt	clarity	sense of direction /confidence	satisfaction or disappointment
Thoughts (cognitive)	vague →		→	focused →	increased interest →	→
Actions (physical)	seeking relevant information exploring →		→	→	seeking pertinent information documenting	

Figure 5.1. Model of the Information Search Process (ISP).

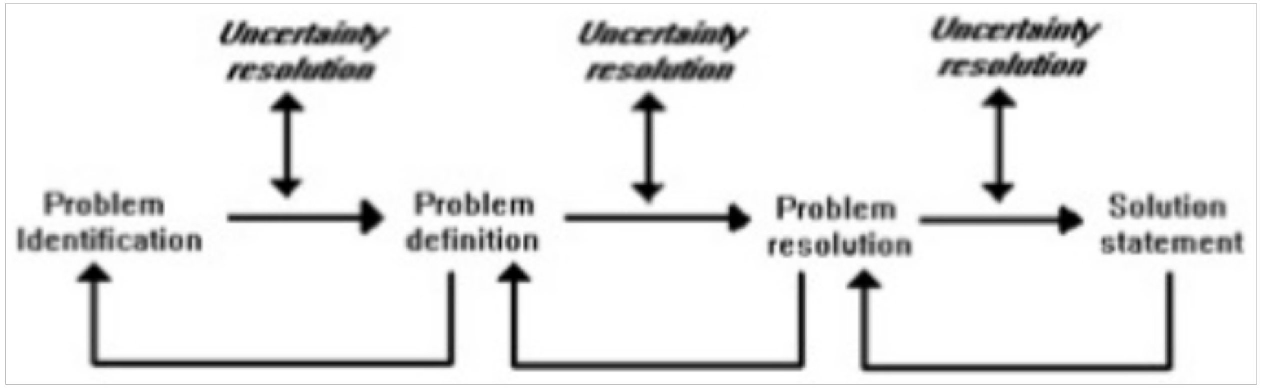
Kuhlthau's Information Search Process



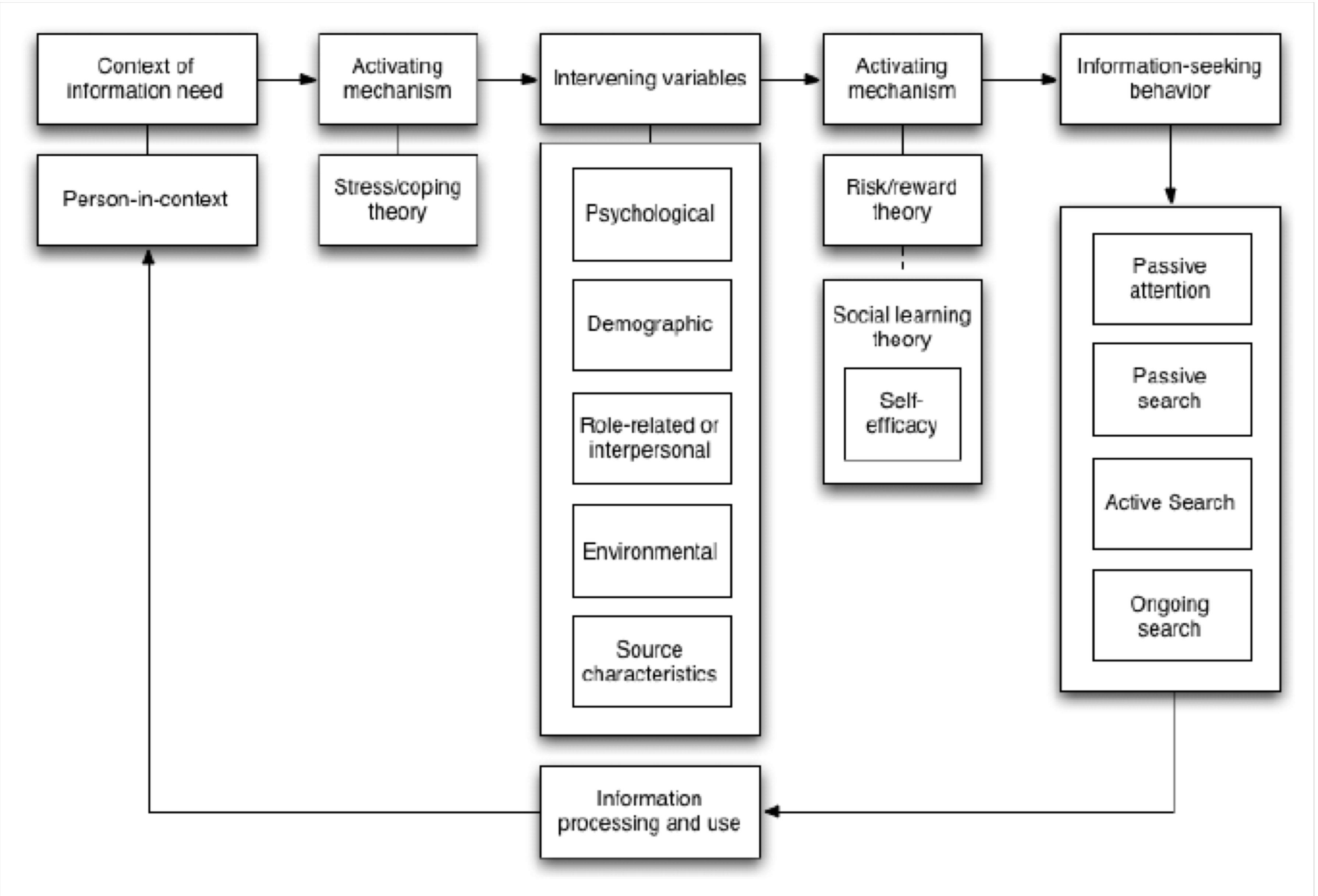
Wilson's Problem Solving Model

- Goal-directed towards problem solving
- Based on a survey of research in the health field
- Users move from *uncertainty* to *certainty* through the problem-resolution process

- Stages:
  - Problem identification
  - Problem definition
  - Problem resolution
  - Solution statement

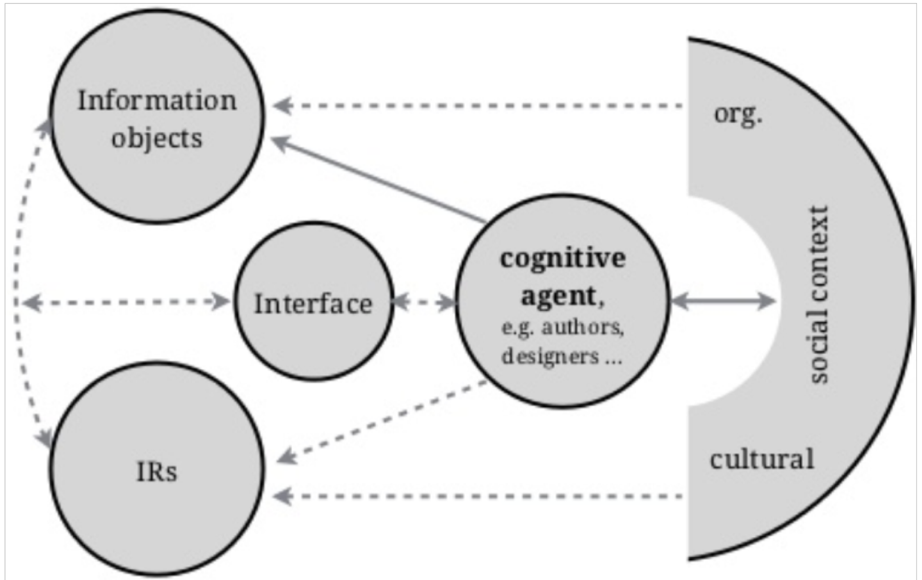


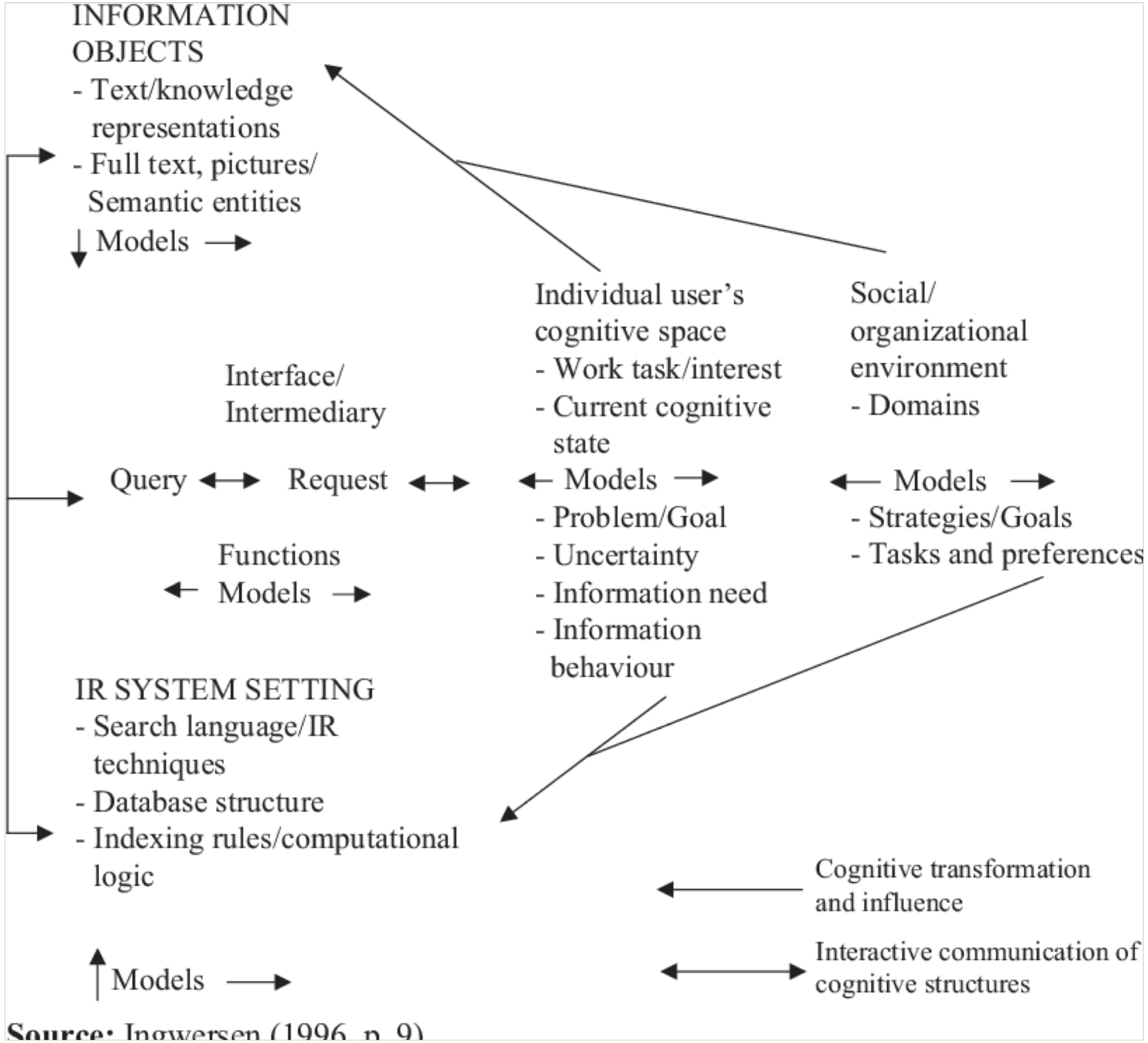
Wilson's General Model of Information Behaviour (1997)



Ingwersen Cognitive IR Model (1996)

- Ingwersen analyzes cognitive information retrieval.
- He focuses on the interaction of mental models.
- He shows the short and the long-term change of these models as well as their drivers.





Saracevic’s model of Stratified Interaction

- Stratified interaction model developed within an overall framework of an **acquisition-cognition-application model** of information use.
- The levels or strata are simplified to three:

1. **surface**, or the level of interaction between the user and the system interface;
2. **cognition**, or the level of interaction with the texts or their representation
3. **situation**, or the **context** that provides the initial problem at hand.

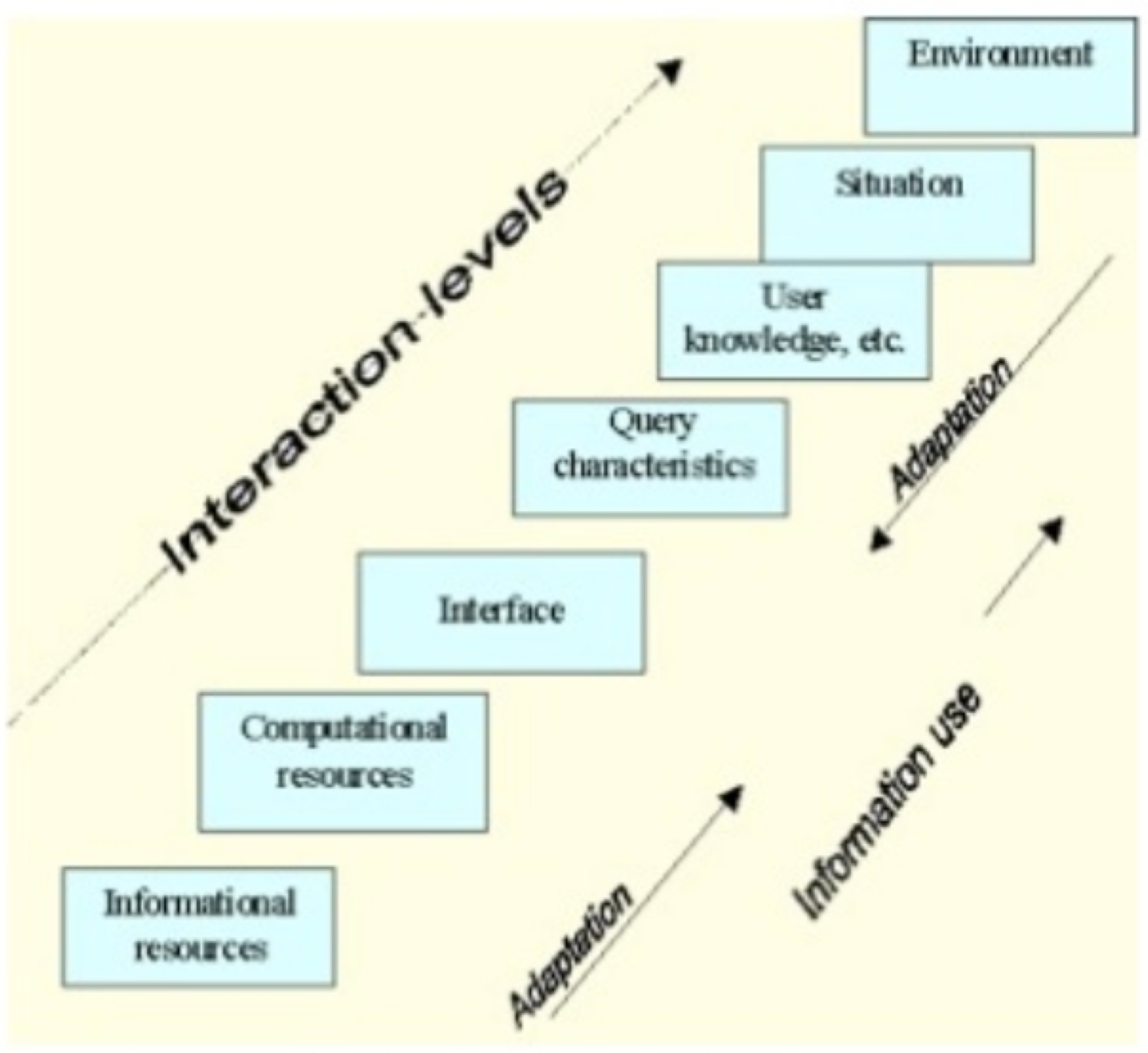


Figure 9: Saracevic's model of stratified

Information Foraging Theory (IFT)

- Information Foraging Theory (IFT)
  - Pirolli and Card – Xerox PARC
  - “an approach to the analysis of human activities involving information access technologies”
  - Derives from **optimal foraging theory** in biology and anthropology
  - Analyzes adaptive value of food-foraging strategies

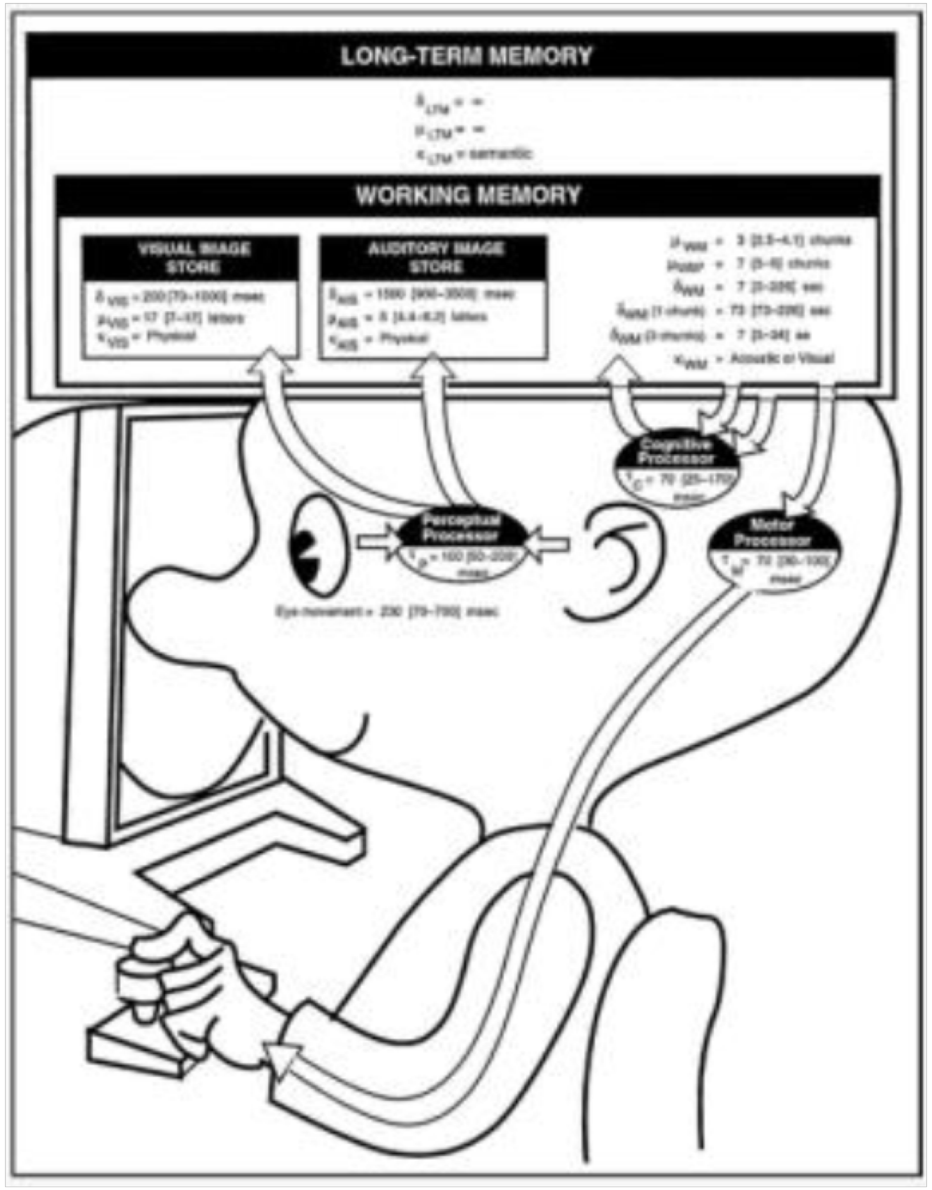
- Analyzes trade-offs in value of **information gained** against the **costs of performing activity** in human-computer interaction tasks
  - And needs models and analysis techniques to determine value added by information access, manipulation, and presentation techniques

- Real information system design problem is not **how to collect more information**, but **how to optimize user’s time**
  - Increase relevant information gained per unit time expended

- IFT provides a relatively “formal” (quantitative) account

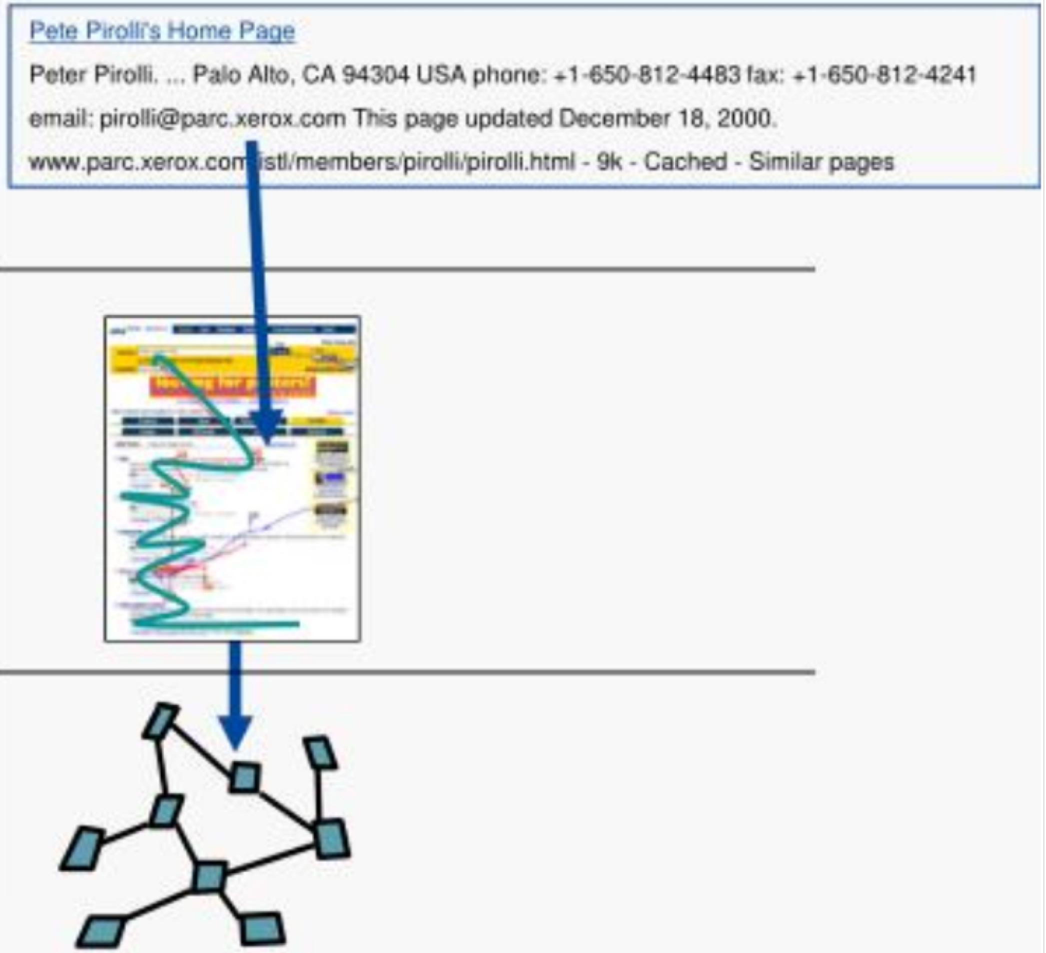
IFT timescales

- Considers “adaptiveness of human-system designs in the context of the information ecologies in which tasks are performed”
    - Ecology, as system; here -- information
- **Timescales** of information seeking and sense making activities:
    - **Cognitive** band (~100 ms – 10 s)
    - **Rational** band (minutes to hours)
    - **Social** band (days to months)



Timescale of Analysis

Time scale (s)	Psychological domain	User Interface Domain
.100-1	• Visual attention • Perceptual judgment	
1-100	• Visual search • Motor behavior	
10-1000	• Problem solving • Decision making	



IFT – An Ecological Perspective

- Time scales of information seeking and sense making activities
  - Cognitive band (~100 ms – 10 s)
  - Rational band (minutes to hours)
  - Social band (days to months)

- As time scale increases, less regard for how internal processing accomplishes linking of actions to goals

- Assumes behavior governed by “rational principles and shaped by constraints and affordances of the task environment”

- An **ecological perspective**, i.e., that behavior is “adaptive” in that it accomplishes some goal

Optimal Foraging Theory - Biology

- Developed in biology for understanding opportunities and forces of adaptation
  - the theory helps in understanding existing human adaptations for gaining and making sense of information
  - aid in task analysis for creating new interactive information system designs

- Optimality models include:
  - **Decision** assumptions
    - Which of the problems faced by an agent are to be analyzed, e.g., whether to pursue a particular type of information (or prey) when encountered, how long to spend
  - **Currency** assumptions
    - How choices are to be evaluated, e.g., information value (food value)
  - **Constraint** assumptions
    - Limit and define relationships among decision and currency variables, e..g., from task structure, interface technology, user knowledge

Information Foraging Theory

- Information foraging is usually a task embedded in context of some other task
  - Value and cost structure defined in relation to the embedding task
  - Value of external information may be in improvements to outcomes of embedding task
- Usually, embedding task is some ill-structured problem
  - Additional knowledge is needed to better define goals, available actions, heuristics, etc.
  - E.g., choosing a graduate school, developing business strategy
- Though use optimality model, not imply human behavior is classically rational
  - I.e., have perfect information and infinite computational resources
  - Rather, humans exhibit bounded rationality, or make choices based on satisficing

IFT – Information Patch Model

- Information patch model – from optimal foraging theory

- Rate of currency intake, $R = U / (T_s + T_h)$
  - U = net amount of currency (value, e.g., food, information) gained
  - T_s = time spent searching
  - T_h = time spent exploiting

- Net currency gain, $U = U_f - C_f$
  - U_f = overall currency intake (gross amount foraged)
  - C_f = currency expended in foraging

- Average rate of currency intake $u = U_f / \lambda T_s$
  - If assume information workers/foragers/consumers encounter information as **linear** function of time (will revisit this)
  - Total n items encountered = λT_s, where λ is rate of encounter with items
  - (will use next slide)

IFT – Information Patch Model

- Average cost of handling items (1st total/rate, the average) :

$$\bar{h} = \frac{T_h}{\lambda T_s}, \text{ and so } U_f = \bar{u}\lambda T_s \text{ and } T_h = \bar{h}\lambda T_s$$

- Let s = search cost per unit time, then total cost of search = sT_s

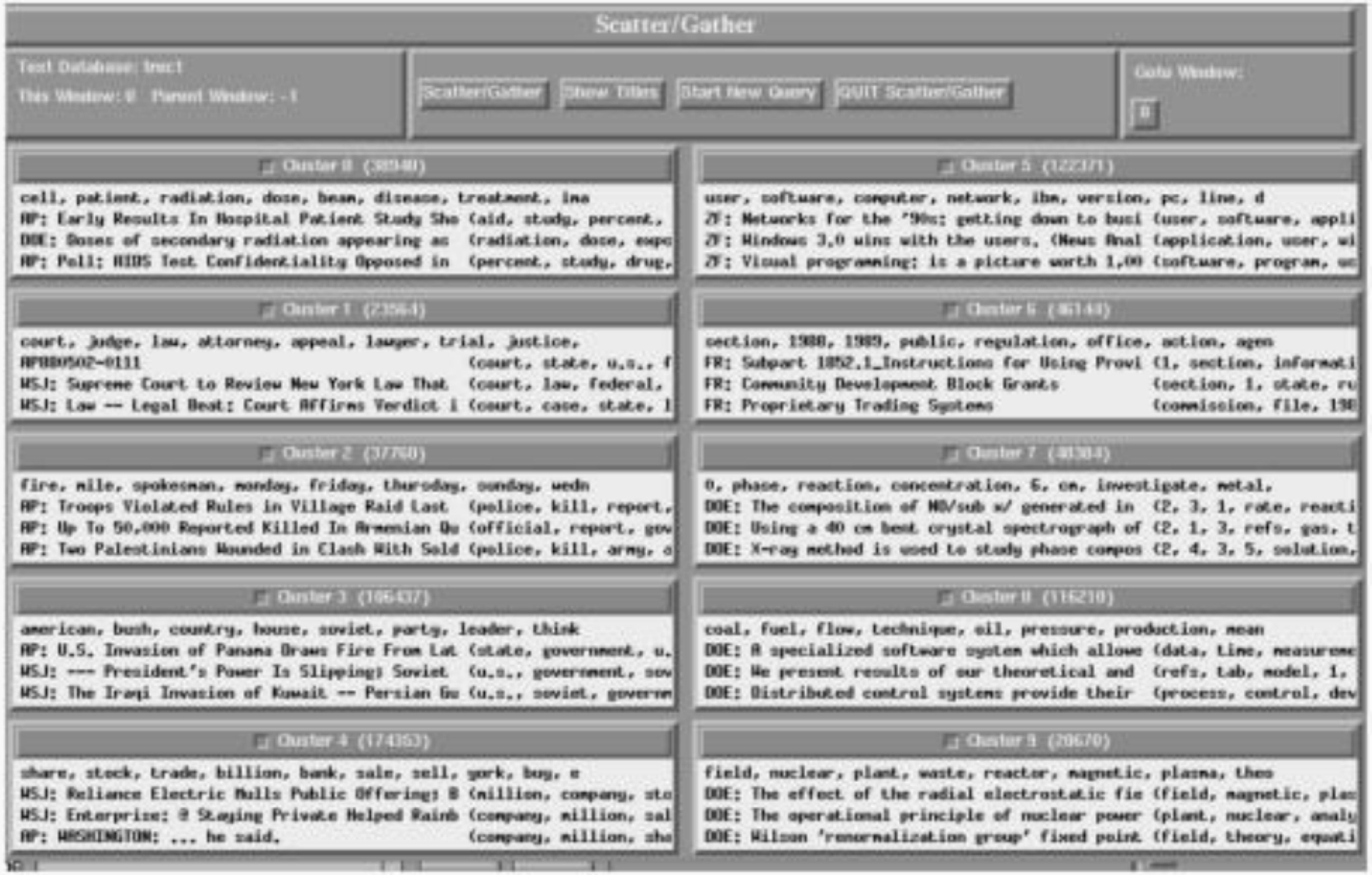
- Then, substituting in equation for R, rate of currency intake:

$$R = \frac{\bar{u}\lambda T_S - sT_S}{T_S + \bar{h}\lambda T_S} = \frac{\lambda\bar{u} - s}{1 + \lambda\bar{h}}$$

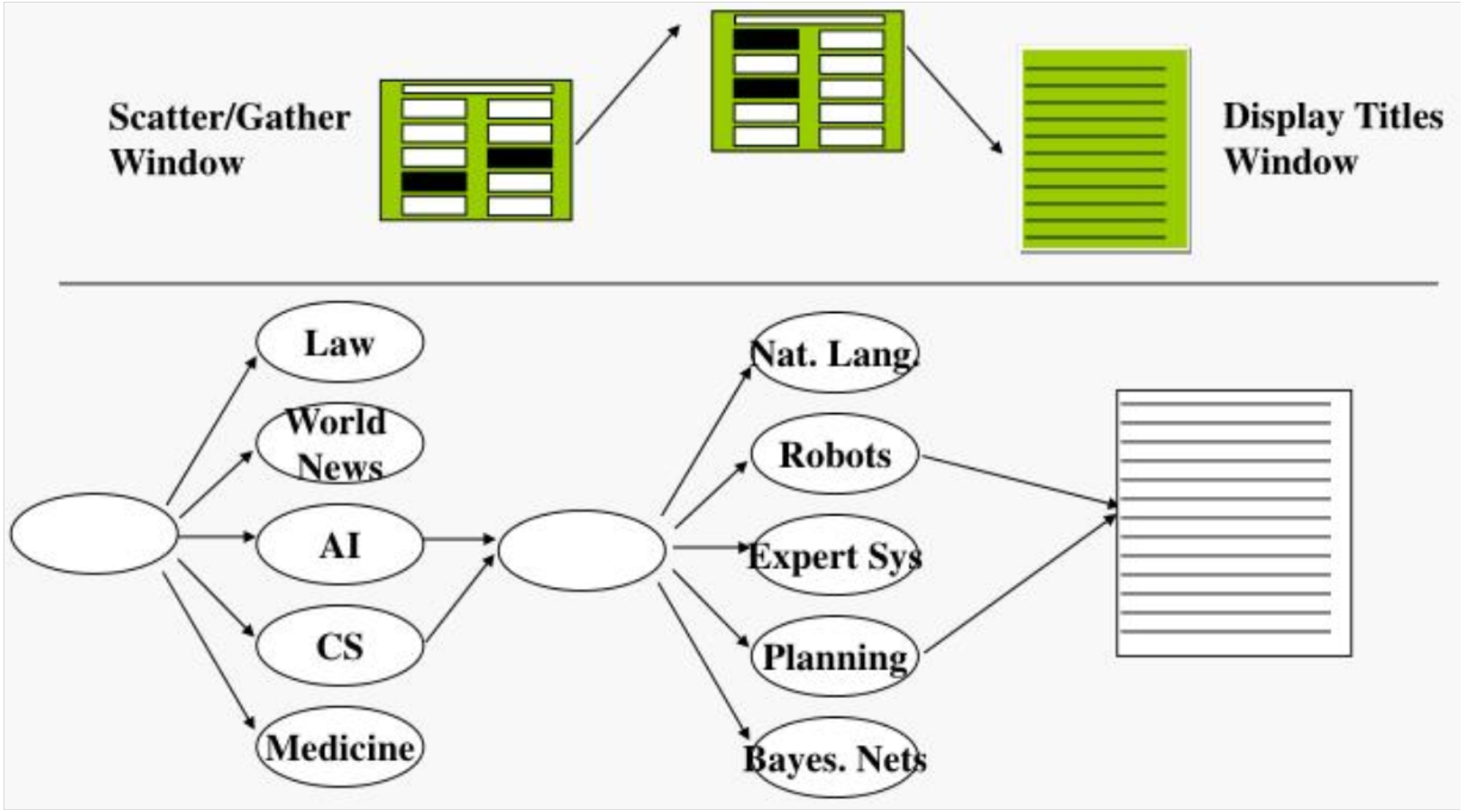
- So, can express R in terms of
  - Average rate of currency intake, u
  - Search cost per unit time, s
  - Cost of handling items, h

An Example: Scatter Gather

- Hierarchical clustering of document
- Users see “overview” of document clusters
- Allows user to navigate through clusters and overviews



Scatther/Gather Task



Optimal Foraging Time in a Patch

- $g_i(t)$, cumulative gain function
  - Amt of information gained in time t
  - $g_A(t)$ = *random order of encounter*
    - *Increase in information equal for all elements*
    - *Hence, constant slope*
  - $g_B(t)$ *and* $g_c(t)$ = *ordered by relevancy*
    - *"Relevant" items, those with higher information content, encountered earlier*
    - *Hence, highest rate of information increase earlier, and rate decreases*
- λ_p, rate of encounter with relevant items
- *x*-axis, travel time between patches
- R_B and R_C = rate of return
- t_c and t_b optimal foraging time
  - Foraging longer in the "patch" not optimal

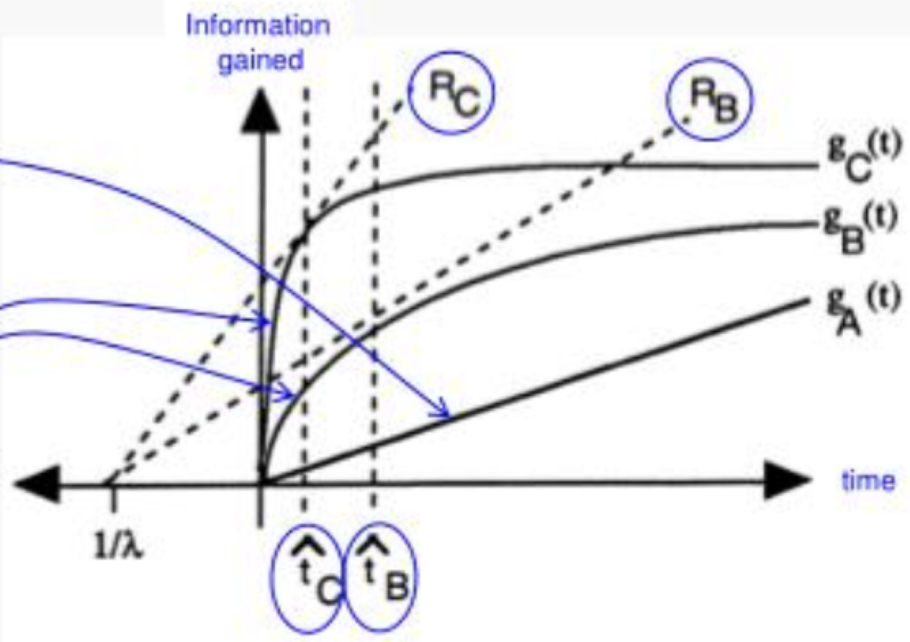


Figure 2. Optimal foraging in information cluster-patches. $g_A(t)$ is the current information-gain function, and $g_B(t)$ and $g_C(t)$ illustrate the effects of ordering by relevancy.

IFT – Cost of Knowledge

- Foraging Efficiency
  - Animals minimize energy expenditure to get required gain in sustenance
  - Humans minimize effort to get necessary gain in information
- Foraging for food has much in common with seeking information
  - Like edible plants in wild, useful information items often grouped together, but separated by long distances in an "information wasteland"
- Information "scent"
  - Like scent of food, information in current environment that will assist in finding more information clusters
- Activities analyzed according to value gained and the cost incurred
  - **Resource costs**, e.g. expenditures of time and cognitive effort incurred
  - **Opportunity costs**
    - Benefits that could be gained in engaging in other activities
    - "Cost of lost opportunity", e.g., if not gaining information about algorithms (or messing with registration system), could be gaining information about software design

IFT - Conclusions

- Information processing systems evolve so as to maximize the gain of valuable information per unit cost
  - Sensory systems (vision, hearing)
  - Information access (card catalogs, offices)

$$\textit{maximize}\left(\frac{\text{information value}}{\text{cost of interaction}}\right)$$