Model Webs

Consultative infrastructures for decision makers and researchers

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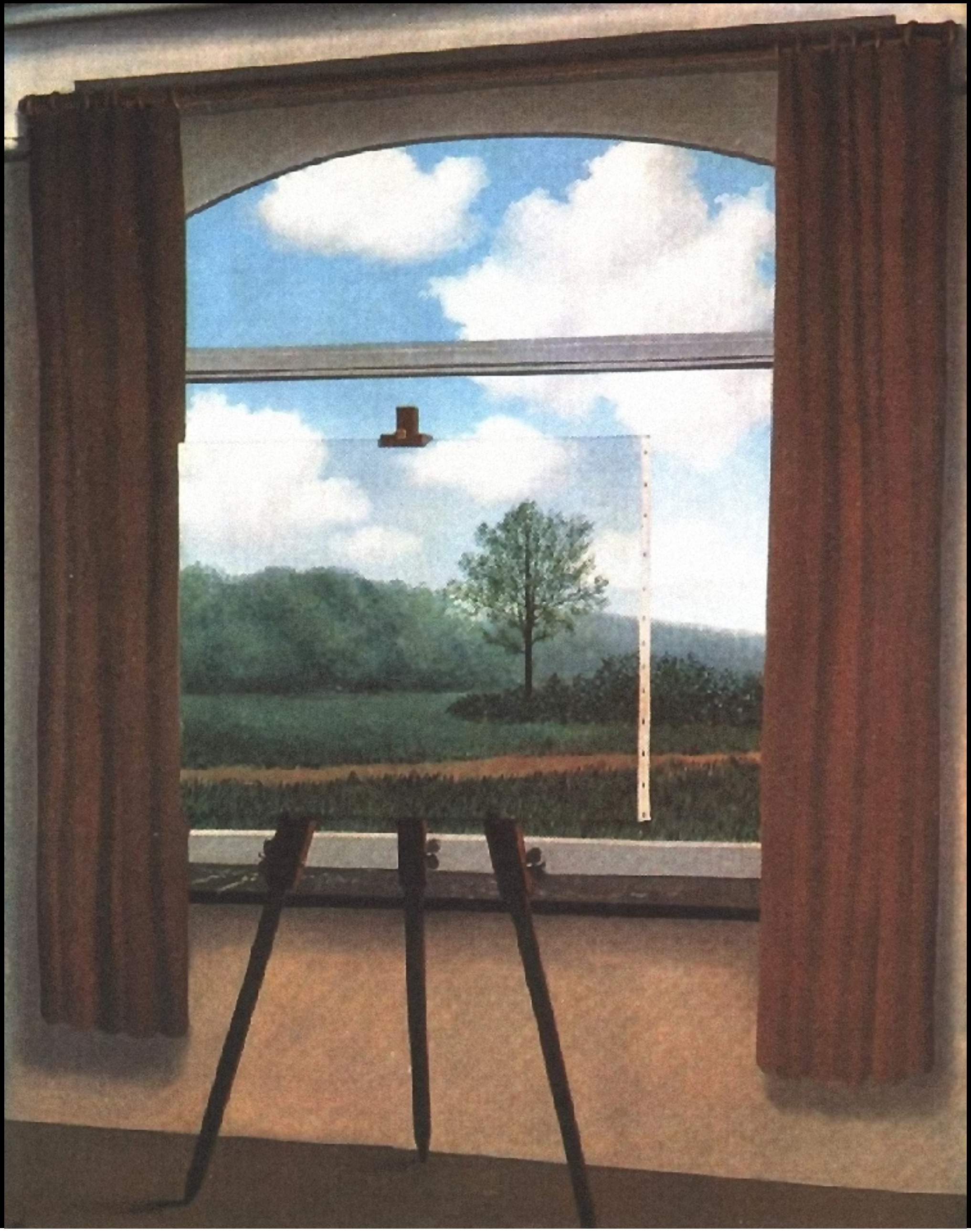
René Magritte: La Condition Humaine



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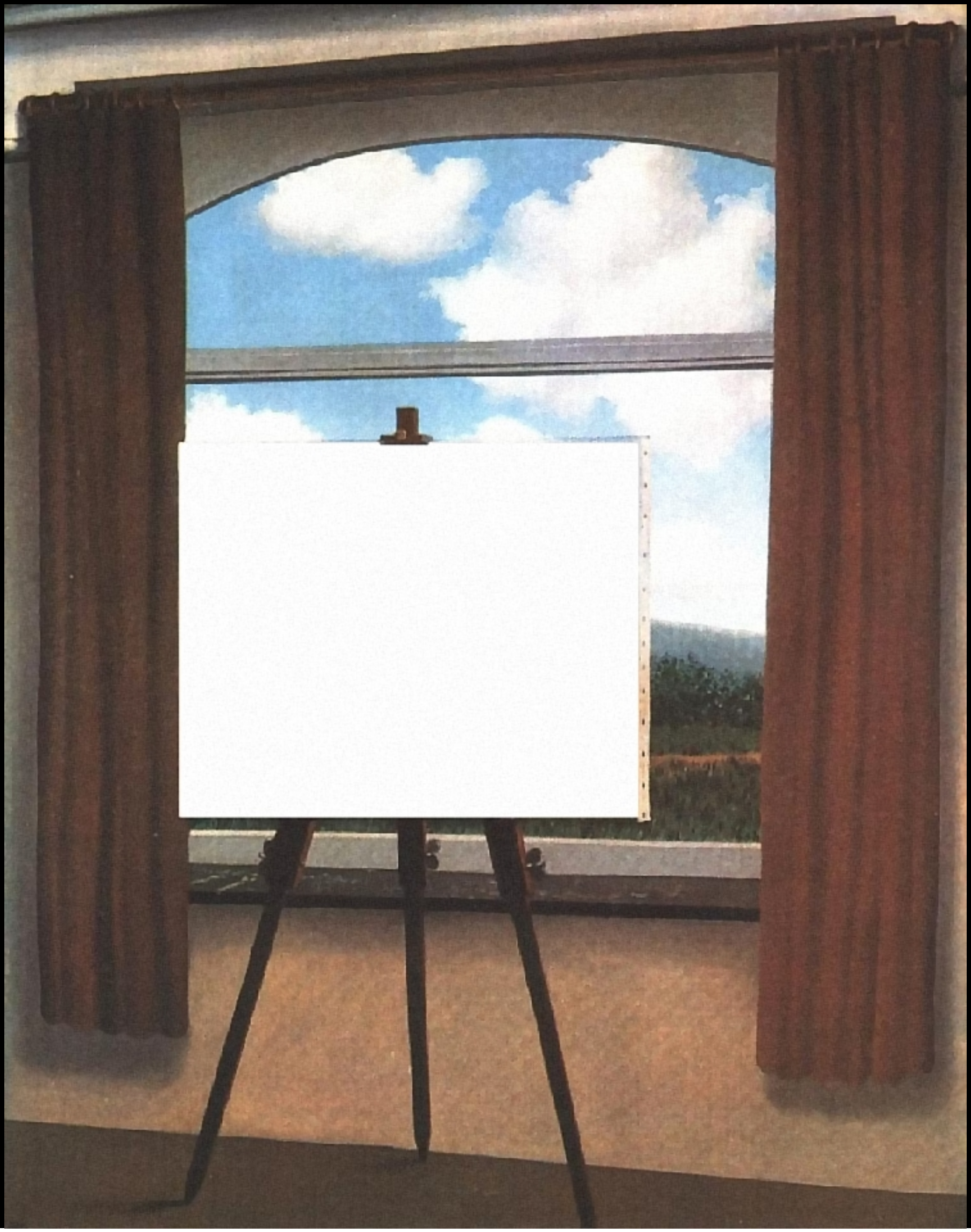

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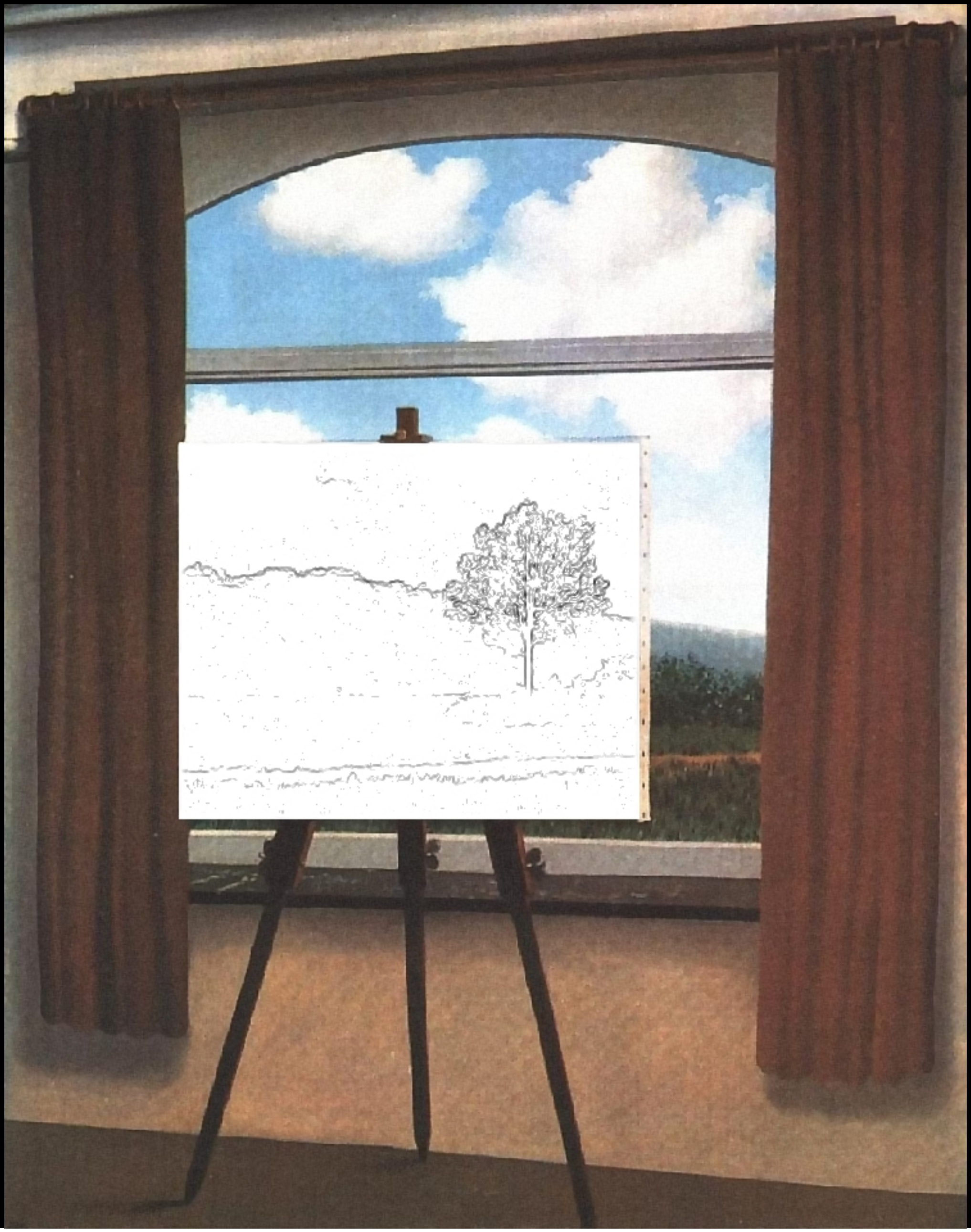

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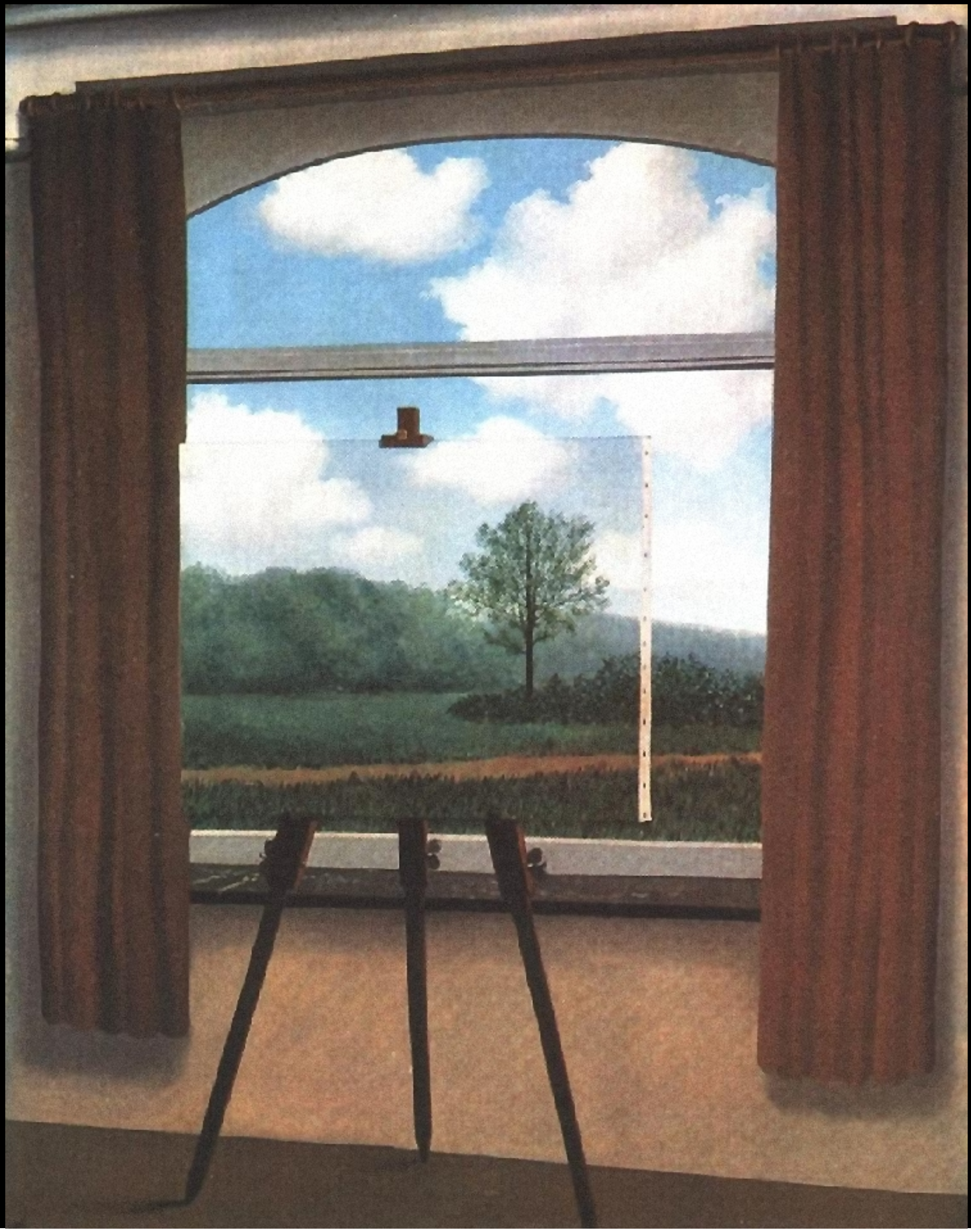

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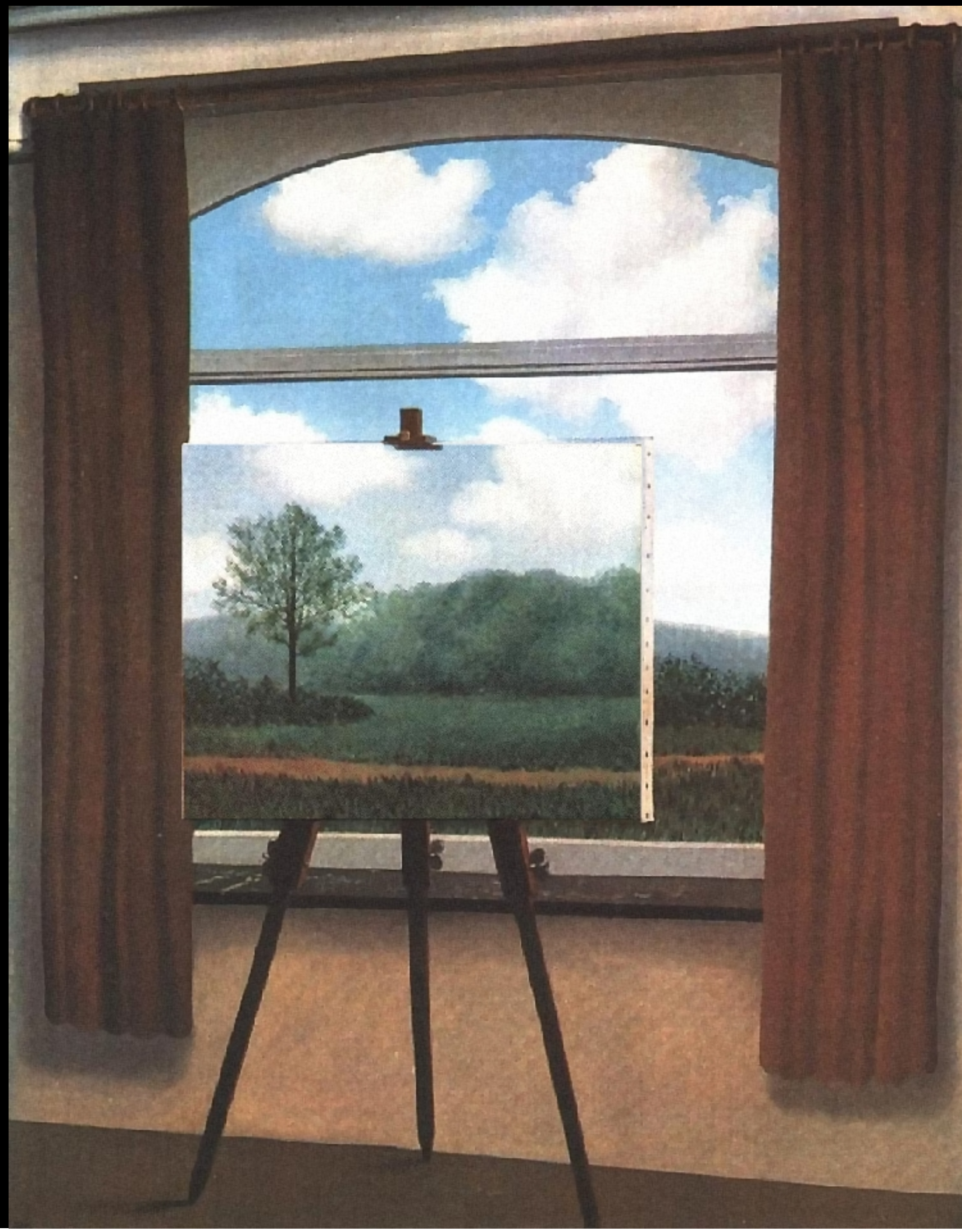

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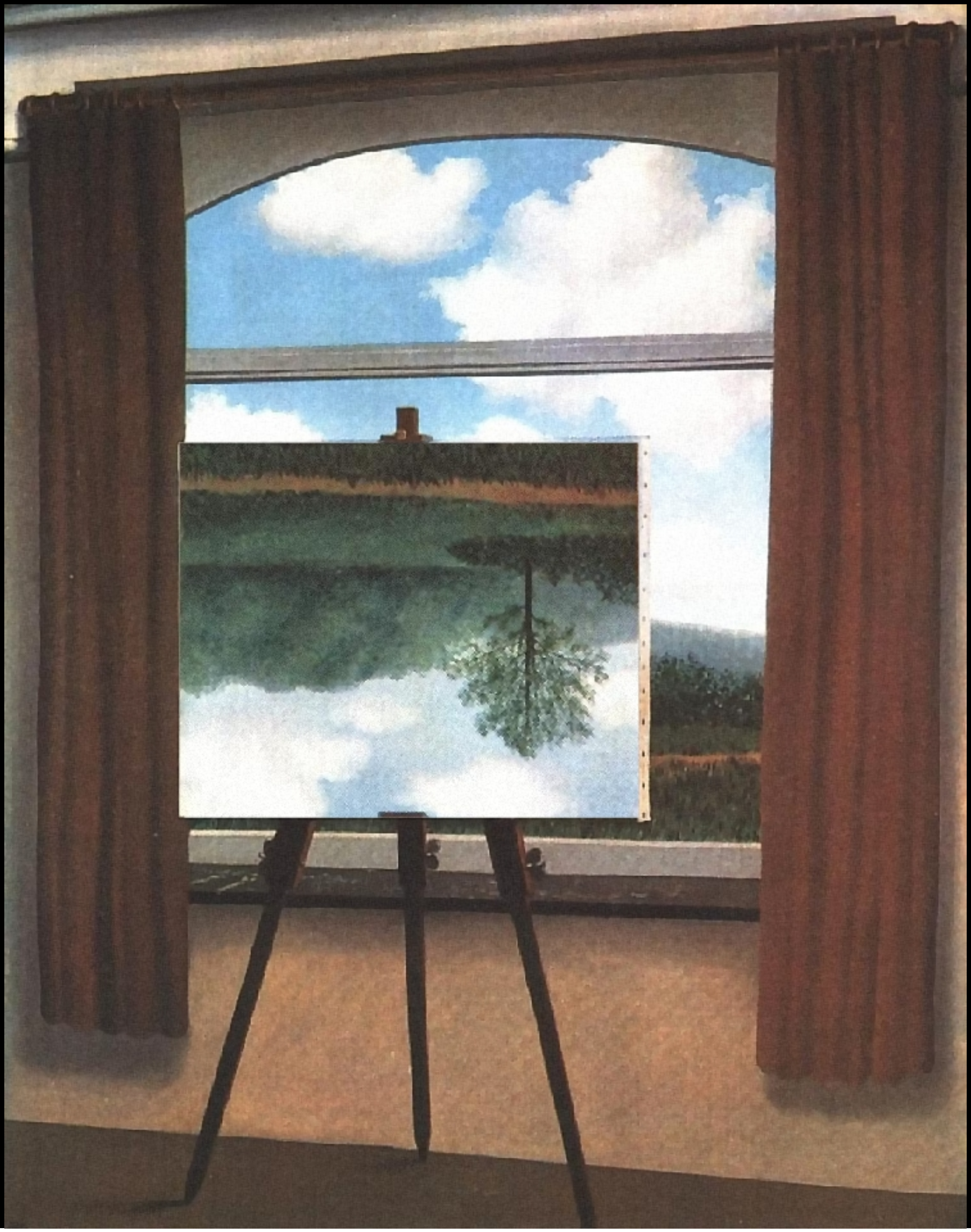

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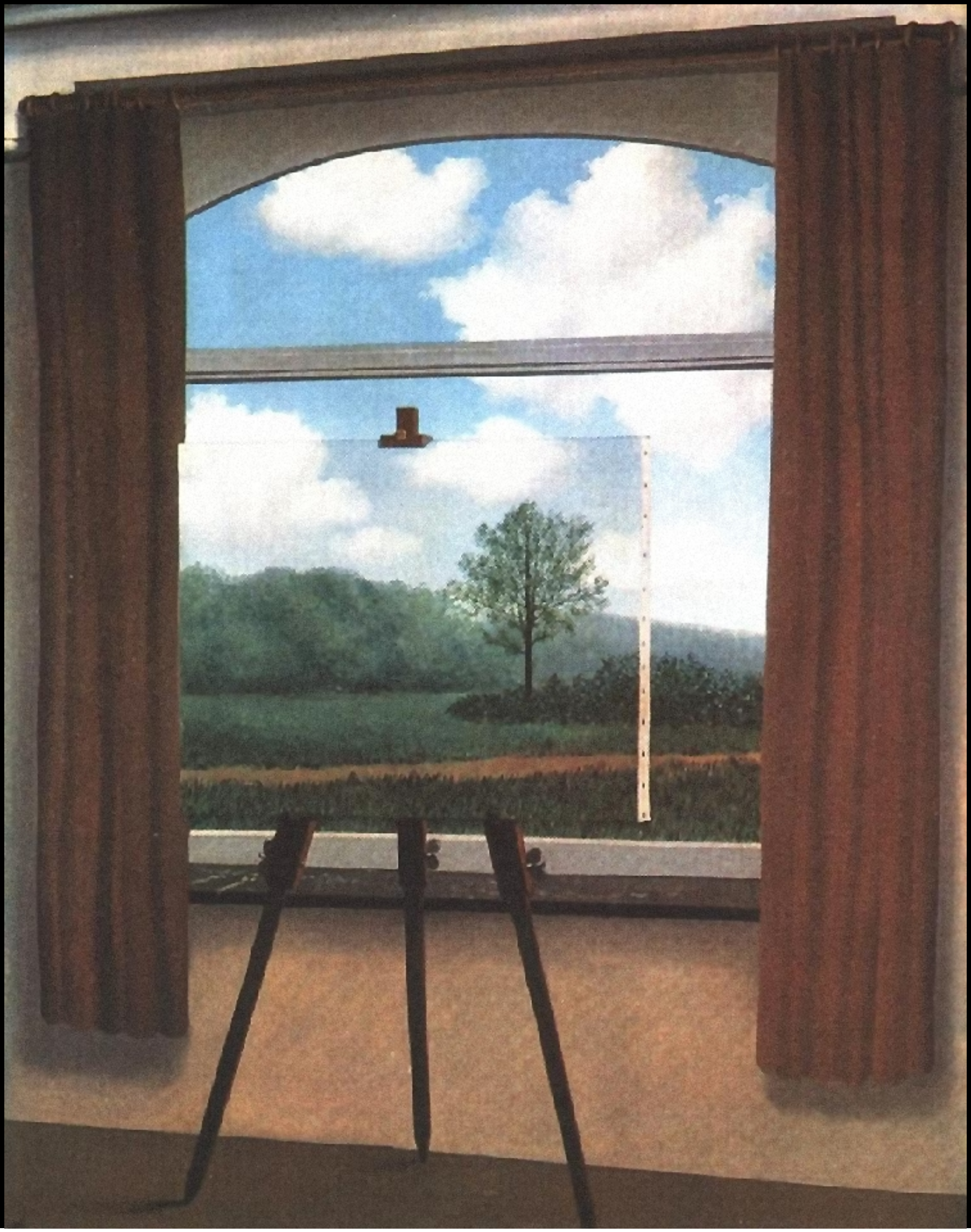

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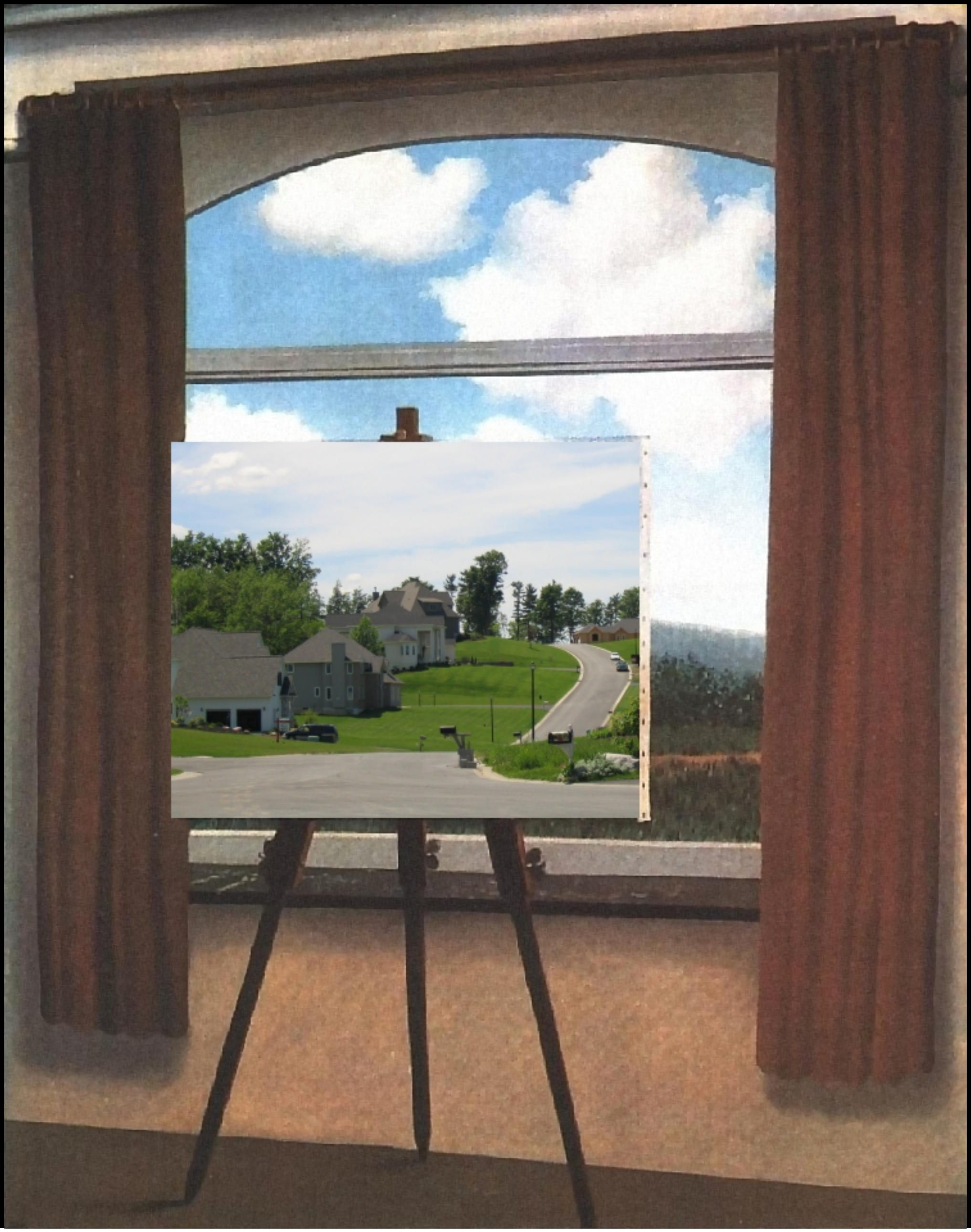

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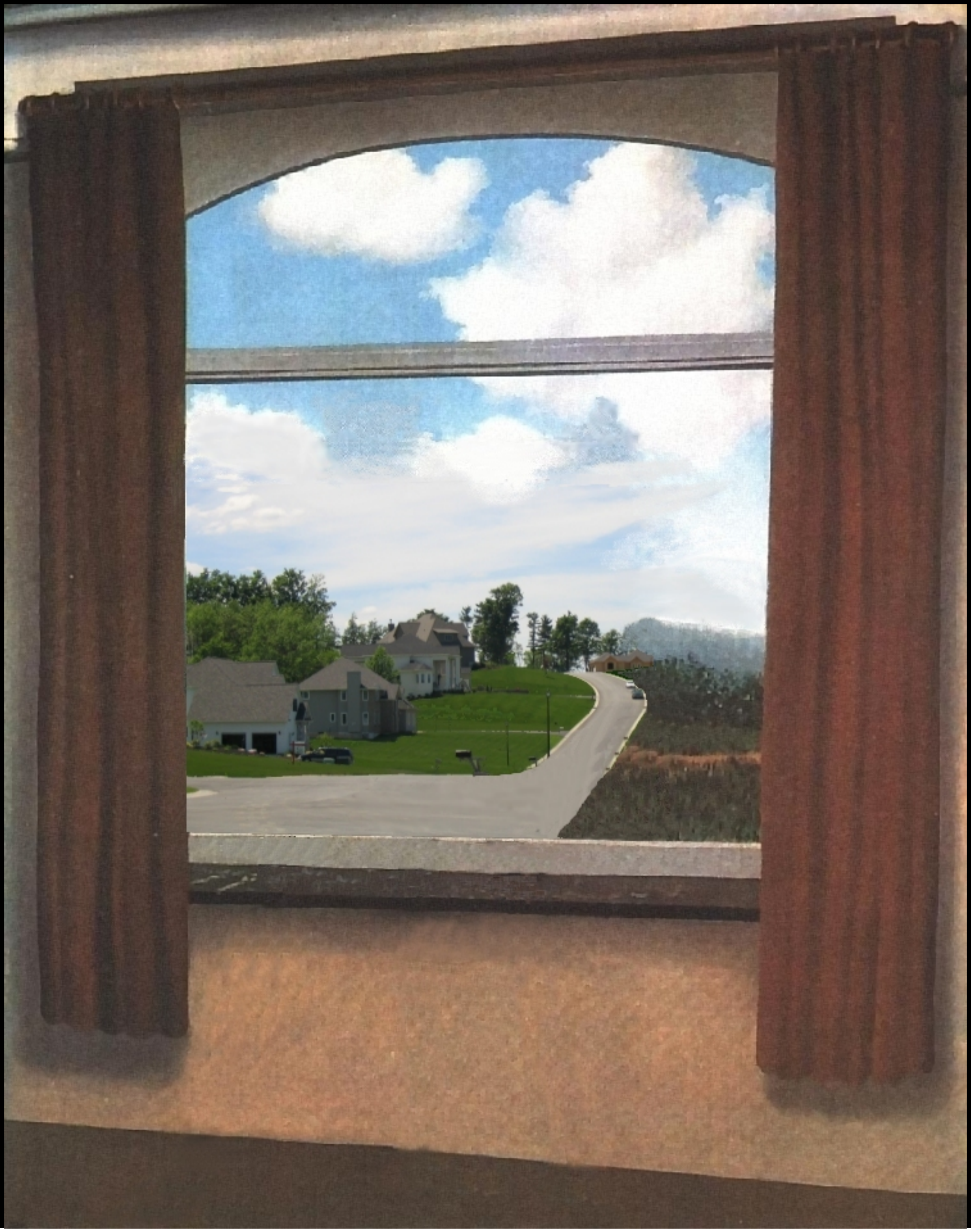
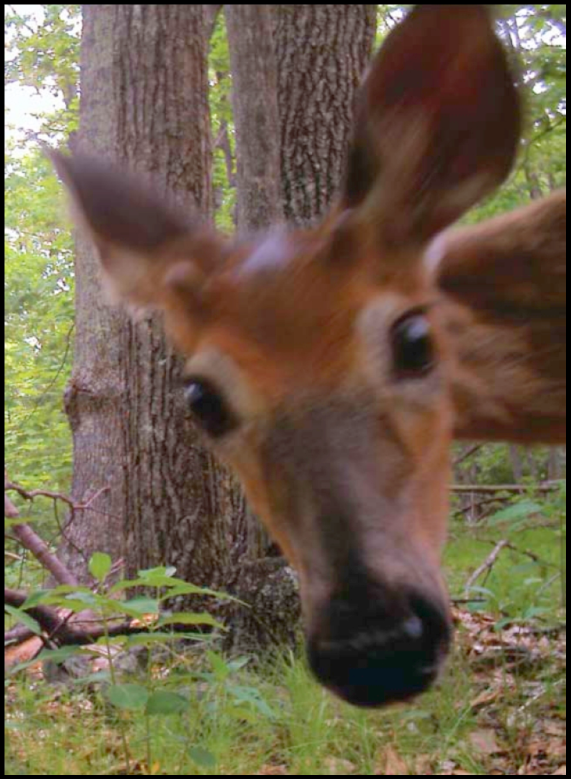


Overview

- ❑ The problem
- ❑ Solutions
- ❑ Model as a service
- ❑ Model web
- ❑ Discussion



1) Access

2) Improved forecasts

What do decision makers want?

1. What will change?
2. What will be the consequences of those changes?

MODELS REQUIRED

Specific Examples

- BCC: What are the ecological and social implications of complete "build-out" in Boulder according to the existing regional zoning plan?
- USGEO: What are the consequences of alternative land management practices on biological diversity in the context of climate change?
- NEON: How do changes in the availability and distribution of the nation's water affect ecological systems?
- DS: How will the boreal forest shift as temperature and precipitation change at high latitudes? What will be the impacts on animal migration patterns and invasive species?

How will water availability

should be targeted to protect the Gurney's Pitta?

forest cover

How will flood risk be affected?

How will fire risk

What do we need to do to restore the landscape of an overgrazed African ecosystem?

fragmentation

bird species?

temperatures in SF be changed?

How many of these questions can be easily answered, or explored, now?

Can a resource manager easily get information on these topics?

Vision

A consultative infrastructure where decision-makers can go for answers to "what if" questions

- **Models + websites**
- **WWW for models**

But achieving this is hard…

The Modeler's Condition

Its hard to make predictions, particularly about the future

How can predictive capabilities be improved, and shared?

Current Situation (Ecology)

Increase sharing & access of models and model outputs

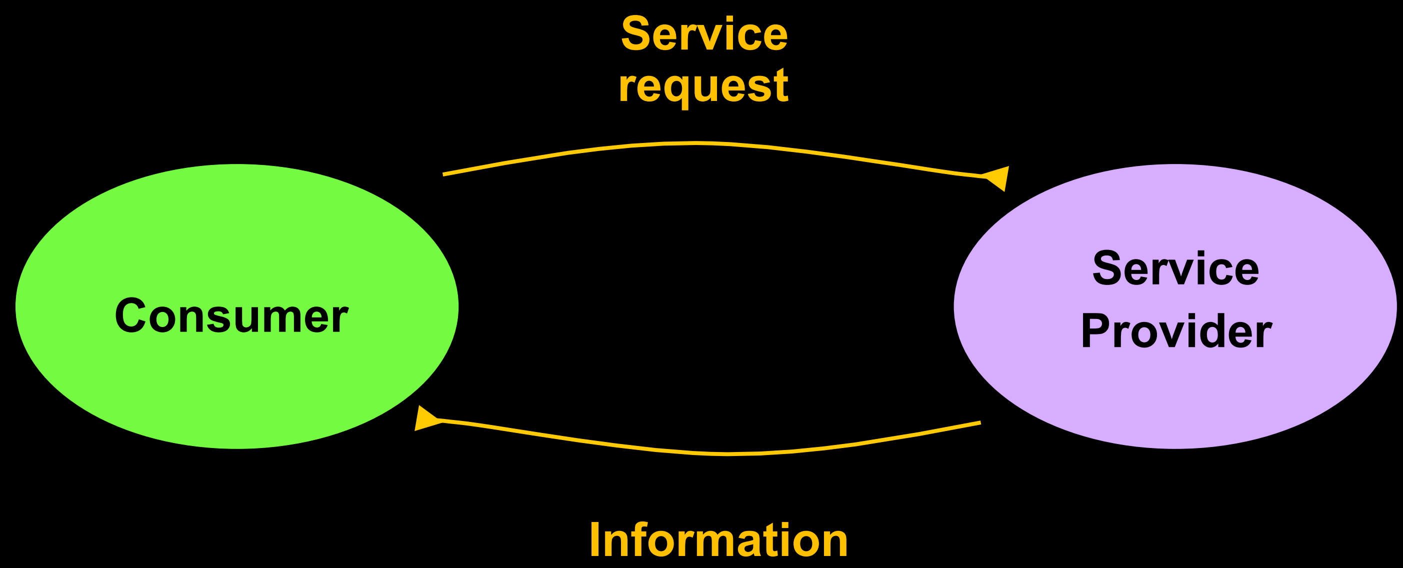
- ❑ **Model output**
  - Sometimes shared
  - Sometimes as a web service

- ❑ **Models**
  - Code sometimes shared (DIY)
  - Rarely available as a service

Approaches

1. Community modeling
3. Virtual modeling environments
4. Model as a service
5. Model Web

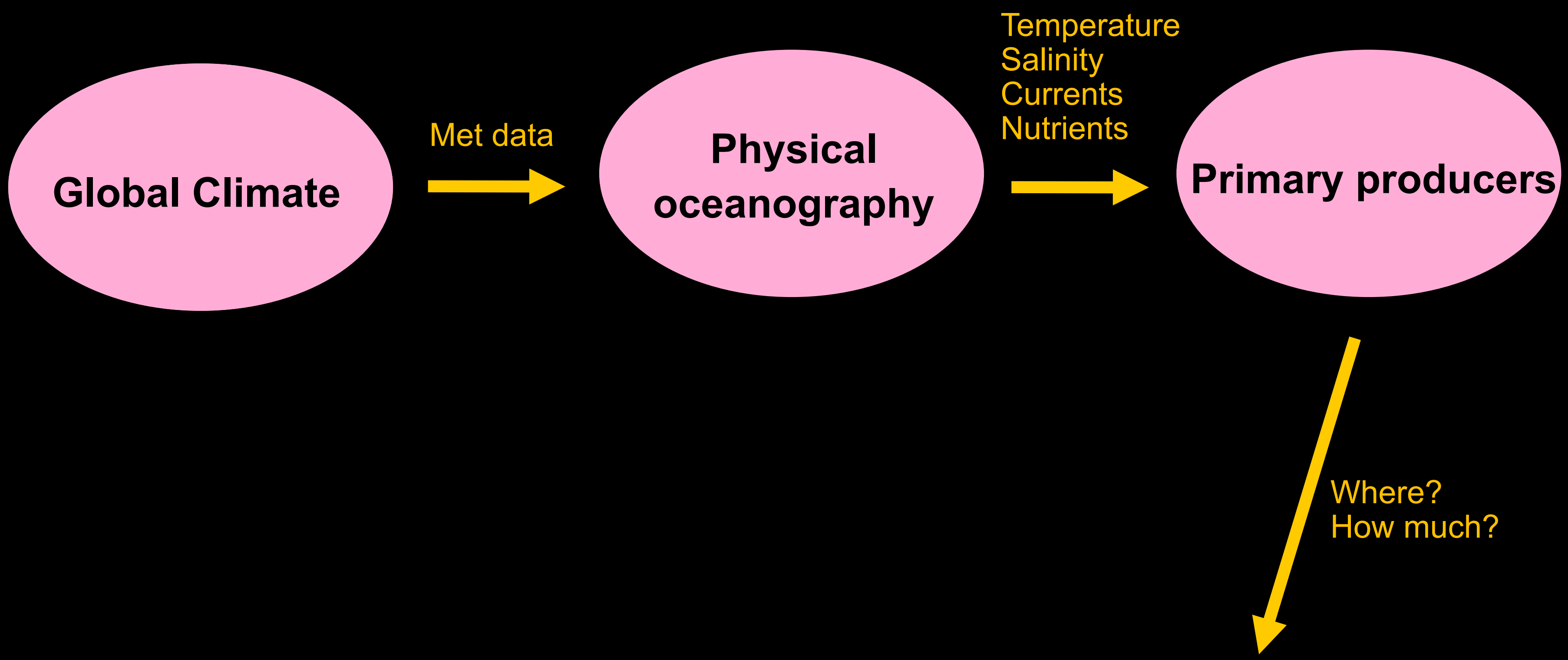
Model as a Service



- Data provider: Easy method for data sharing
  - Well-known technology
- Data consumer: Improved access
  - To people
  - To other models

Not for all models

Model as a Service



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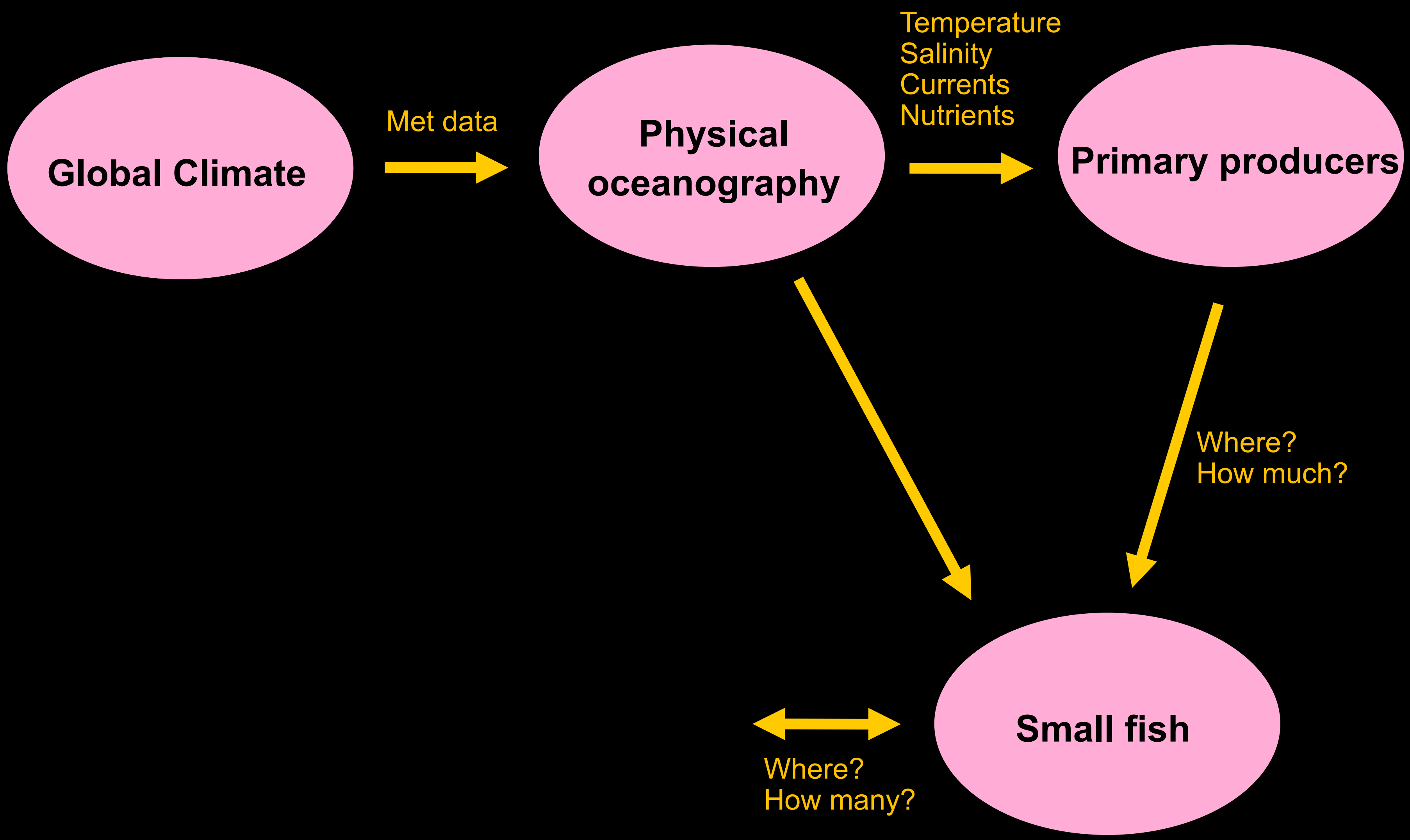

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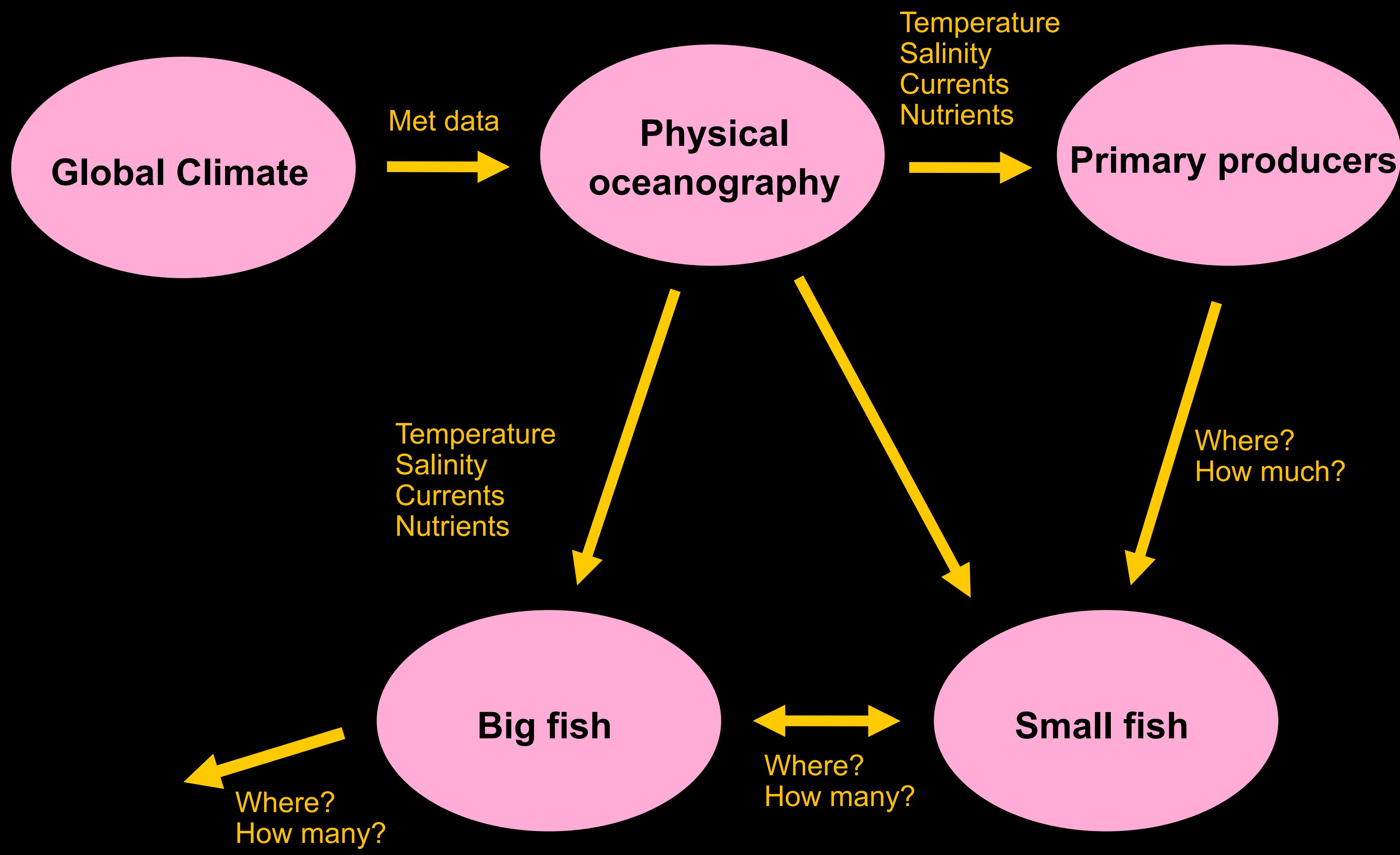
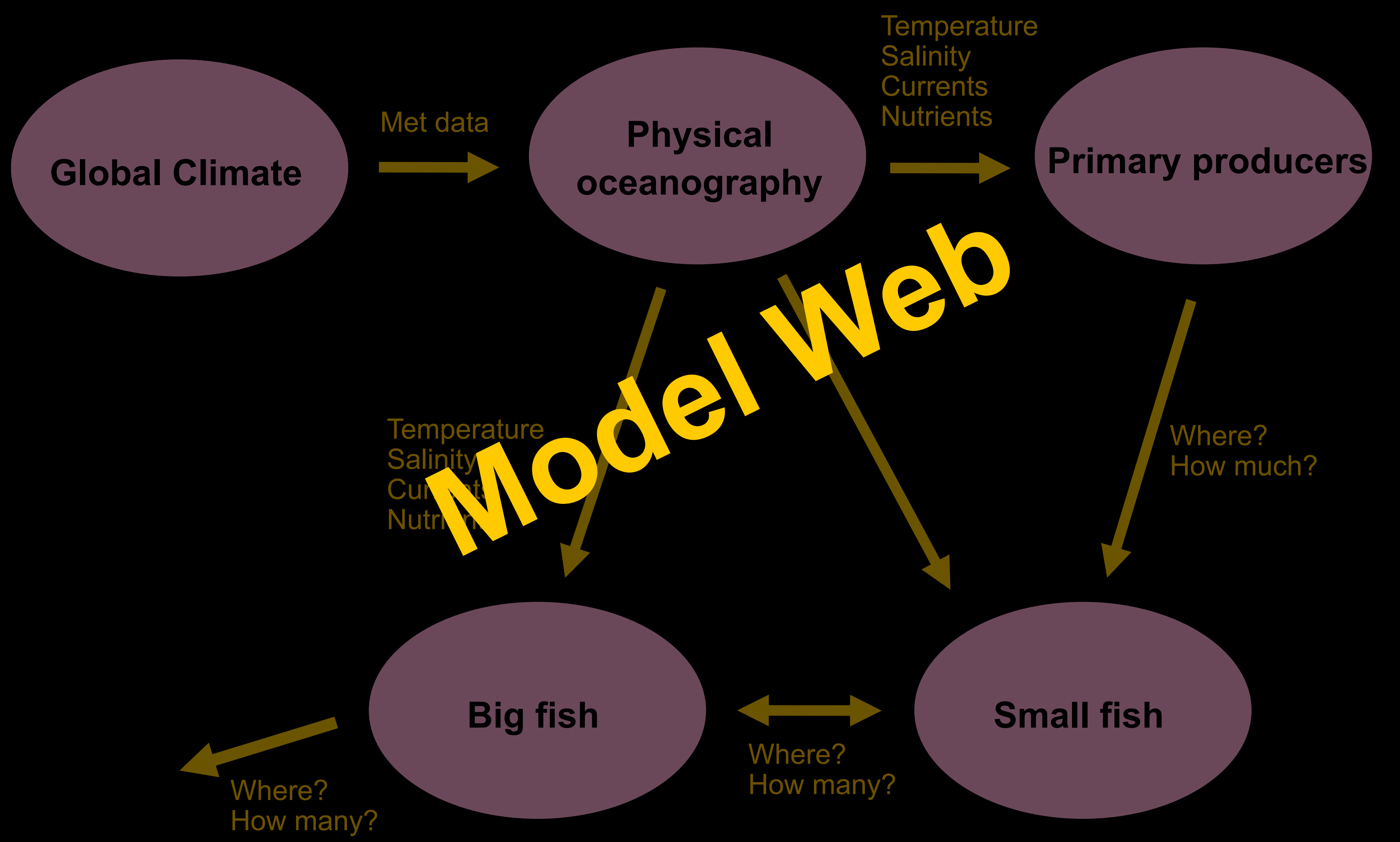
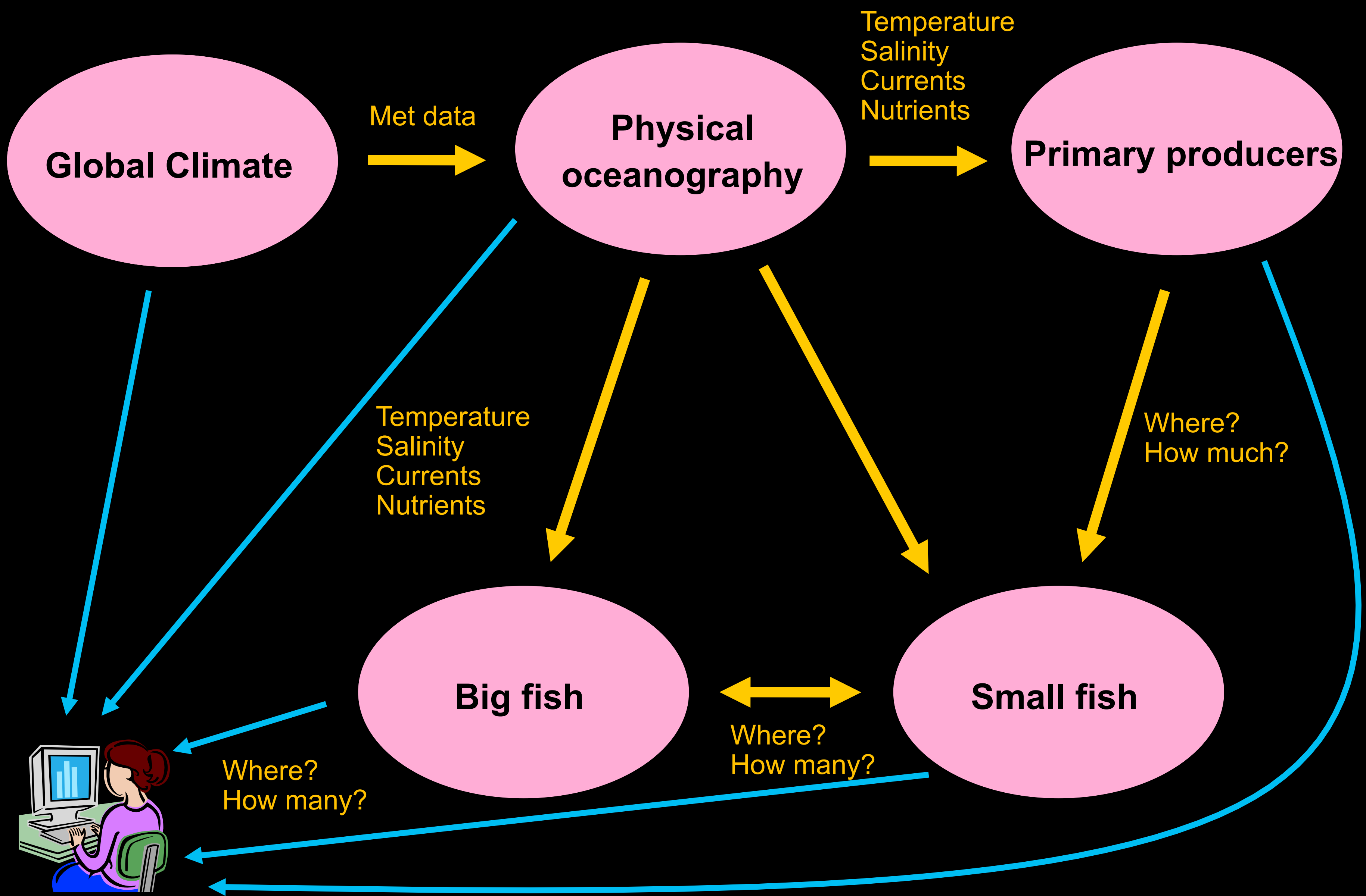


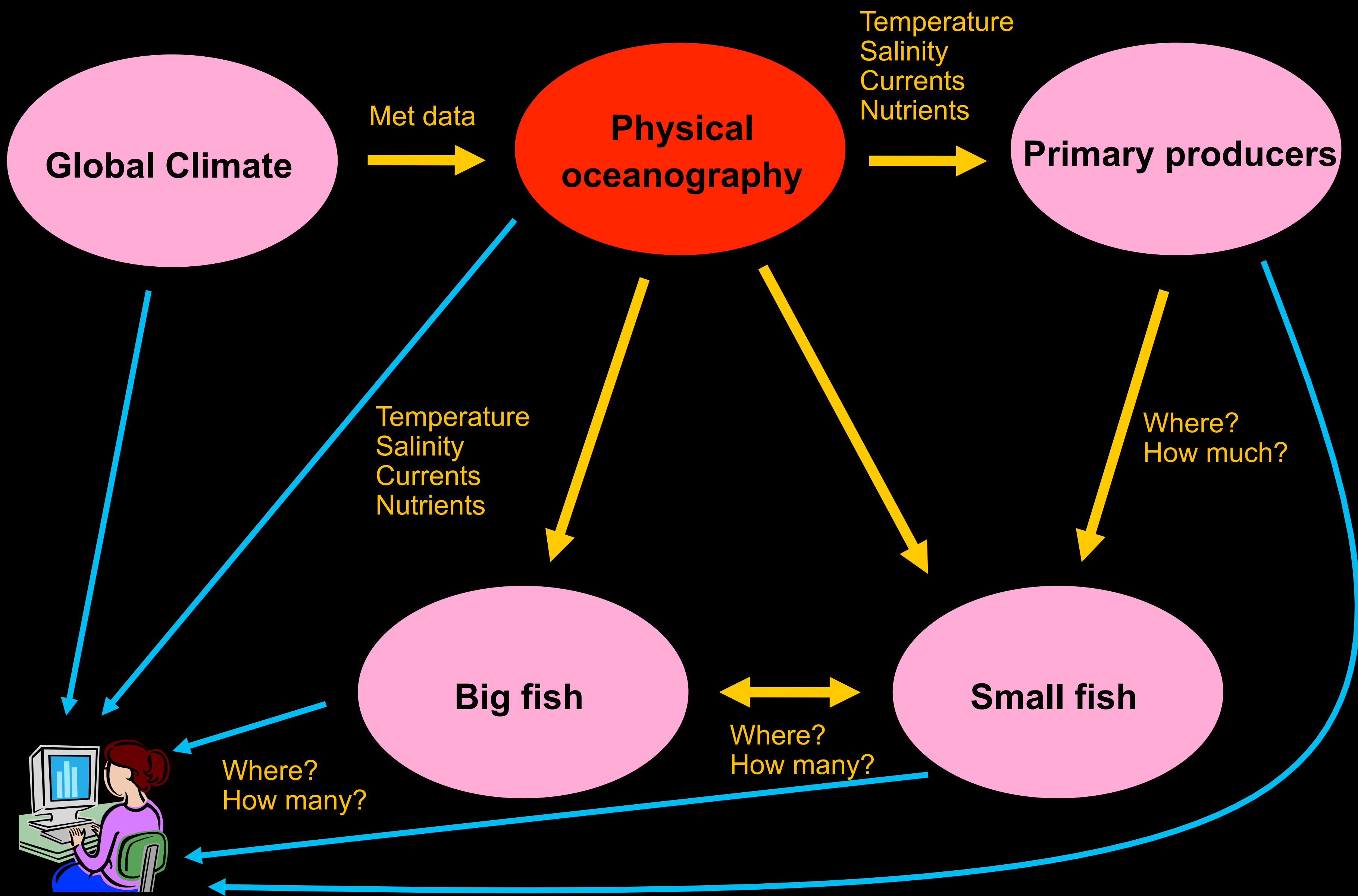
Model as a Service



Consultative Infrastructure



Keystone Models



Model Web

- Increases access and sharing
- Decreases reinvention
- Facilitates
  - Improved forecasting
  - Model experiments, comparisons, ensembles
  - Assessment of management options
  - Consequences of change
- WWW for models

Model Web Key Characteristics

- Distributed network
- Communication via web services
- Websites provide access to researchers, managers, public…
- Organic growth (with guidelines)

And…

- Greater modeler interaction
- More users → more feedback → faster improvement

Web 2.0

Web 2.0

- Collaboration
- Sharing
- Interactivity, feedback
- Communities
- “Crowd sourcing”

- Web 3.0?
  - Semantic Web → Model Web

Life Cycle

Cowboy-Fascist Continuum

Cowboy

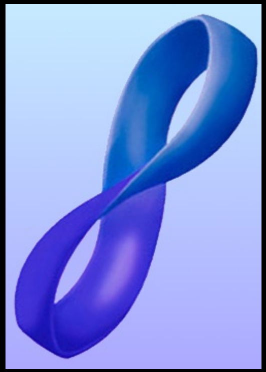
- Complete freedom
- Minimal barrier to join
- Informal, little planning or regulation
- Partial automation

Fascist

- Complete control
- Higher barrier to join
- Large investment in planning and regulating
- Full automation

Getting Started

- Start simple
- Minimize barriers to entry
- Resist complicated metadatsets
- Don't require new technologies
- Let standards emerge

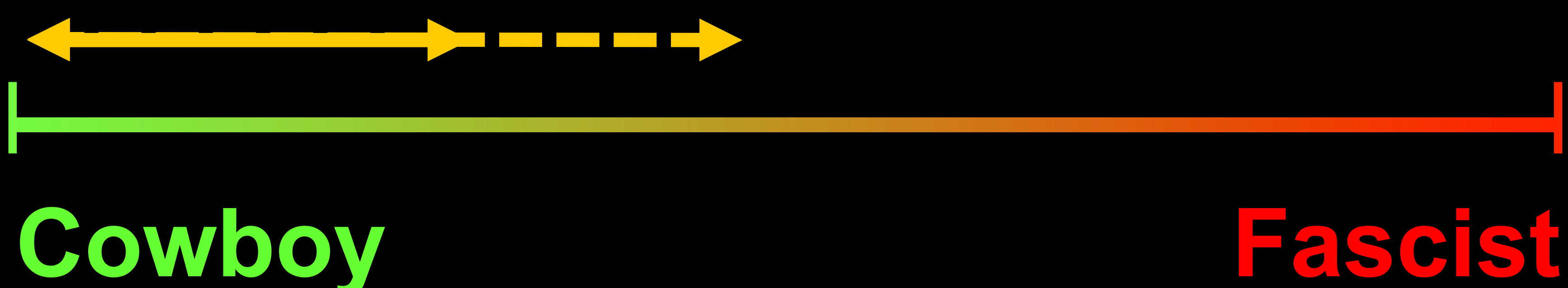


- Keystone models
- Small, planned focused webs

} "Bootstrapping"

Growth Phase

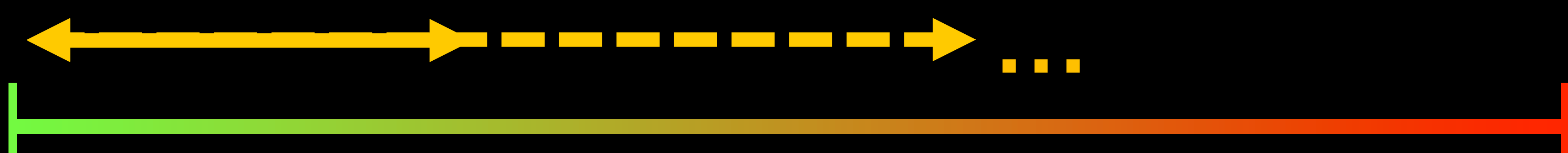
- Individual models added
- Small, planned webs added
- Good models/webs become popular
- Continual feedback and improvement
- Gradual increase in automation and control



Mature Phase

- Growth continues
- Some parts highly automated
- Other parts simple, raw
- Virtual Modeling Environments connected

- Have a consultative infrastructure



Cowboy **Fascist**

Challenges

- ❑ Uncertainty
- ❑ Model interoperability and harmonization
- ❑ Security?
- ❑ Cultural barriers
  - Attitudes towards sharing, incentives
  - Cross-discipline collaboration
  - Stovepiped funding

Current State

- Early days
- Building some components
  - UncertWeb
  - EuroGEOSS
  - e-Habitat
- Planning pilot ecological model web
- AGU session on Ecological Models
- Community for Integrated Environmental Modeling

Basic Principles

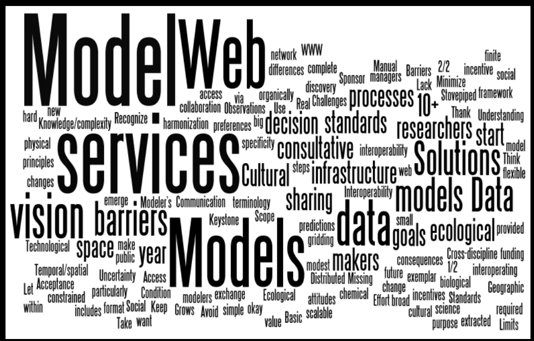
- Use the WWW as an exemplar
- Think big, start small
- Increase…collaboration, interoperability, sharing, access
- Keep it simple, flexible, scalable

Wrap-up

- ROI for models can be increased with greater sharing and access
- Model Web is a vision
  - WWW for models
- Biggest obstacles are cultural
- Start with minimal barriers to entry
- Gradually grow, converge on vision

Word cloud summary

http://www.wordle.net/



Backup Slides

Complementary work

- Community modeling
  - CHyMP: Community Hydrologic Modeling Platform
  - Community Land Model
- ESMF: Earth System Modeling Framework
- OpenMI
- GEOSS: Global Earth Observing System of Systems

Precedents: Numerical weather prediction

- 1904 First proposed → skepticism
- 1922 Detailed
- ~1950 First performed
- 1958 Became useful
- 1970s Became good
- Now Global infrastructure

Barriers to Interoperability

- Data format
- Data terminology
- Missing data
- Temporal/spatial gridding
- Standards
- Sponsor goals
- Model purpose
- Effort required
- Lack of incentive
- Acceptance
- Cultural differences

Technical

Non-technical

Quality assessment

- Formal assessments of models
- Reputation/word of mouth
- User ratings

- User feedback
- Competitive improvement for similar models

Model Web	"Traditional"
Harmonization of components a lot of work	Harmonization of components a lot of work
Communication by web services	Communication by API/system calls
Dynamic, interoperable system of systems	Static, isolated, integrated systems
Loosely coupled components	Tightly coupled components
Distributed system lacking centralized control	Centralized system controlled by developers
Open system. New components added by anyone	Closed system. New components only added by system developers
Organic and opportunistic growth, similar to WWW (though within a guidance framework)	All growth planned and executed by developers
High level of component reuse—once harmonized with other components a component is available to everyone	Low level of reuse; once harmonized all components remain within the closed, tightly coupled system
Higher level of data sharing due to availability of intermediate products	Lower level of data sharing due to focus on specific questions and tightly coupled components so that only final products are shared
Indeterminate growth	Determinate growth as defined by developers
Long term evolutionary process that gradually converges on higher levels of interoperability	Shorter term development process with complete interoperability at delivery
Leads to a shared modeling infrastructure accessible by all	Leads to isolated model systems available to a few
Untrained users may misuse models or outputs	Misuse rare because users and developers are typically the same
Unsuitable for tightly coupled systems that require intensive data exchange between components	Better for tightly coupled systems with intensive data exchange due to co-location of components

Two Levels of Ecological Model Taxonomy

Climate	Coupled climate models, Atmospheric, Ocean, Terrestrial, Ocean currents…
Physical, Physiological, Chemical, & Ecosystem	Carbon, Productivity, Hydrology, Phenology Landscape, Disturbance, Soil, Succession…
Species & Populations	Niche/distribution, Abundance, Population, Pollinator, Pest, Invasive species, Richness…
Community & Foodweb	Trophic, Predator/ prey, Competition…
Socio-Economic	Road-building, Poverty, Census, Species introduction, Economic growth…

Weather forecasting

BC — **Observations → conceptual models**

- Improved observations
- Improved science

1830s — **Telegraph allows sharing of observations**

Mid-1800s — **Network infrastructure → routine sharing, forecasts**

Early 1900s — **Concept of Numerical Weather Prediction proposed**

1955 — **NWP goes operational**

1958 — **NWP becomes useful**

- Improved observations
- Improved science
- Faster computers

Now — **Global infrastructure → share observations, forecasts**

Ecological forecasting

Principle of Gradual Convergence

- Not necessary to completely fulfill vision
  - Benefits begin immediately
- Cannot be achieved quickly
  - Gradually converged upon

How to encourage a Model Web

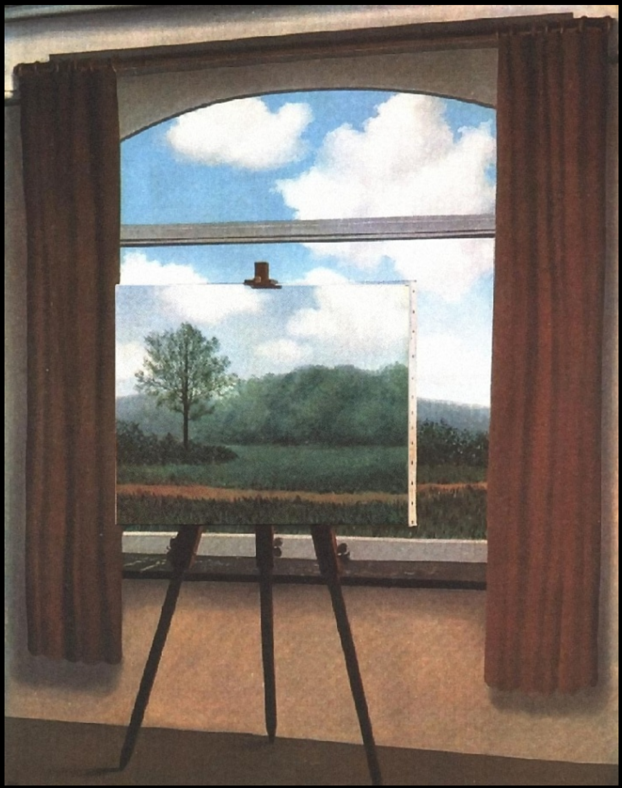
- Keep entry barriers low
- Shift culture towards expectation of sharing
- Increase model interoperability
  - Cultural problem--not technical
- Refine appropriate web services
- Keep it simple, flexible, scalable
- Address other challenges

“We are not out to predict the future,

but to create it.”

Cornell et al, 2010. Developing a systematic ‘‘science of the past’’ to create our future. Global Environmental Change 20 (2010) 426–427

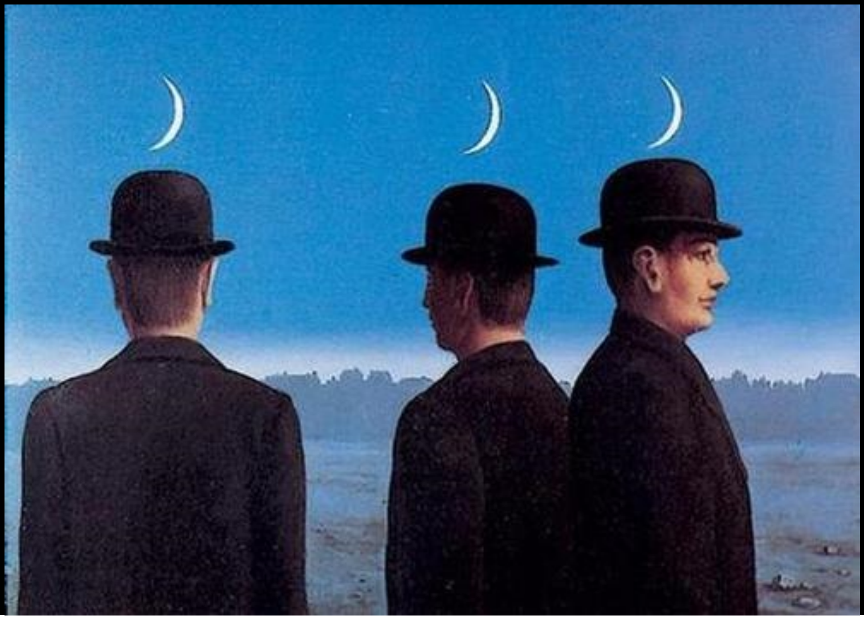
Thank you



Why is the WWW so successful?

- Easy to share and access information
- Provides wonderful information

- Simple, flexible, scalable



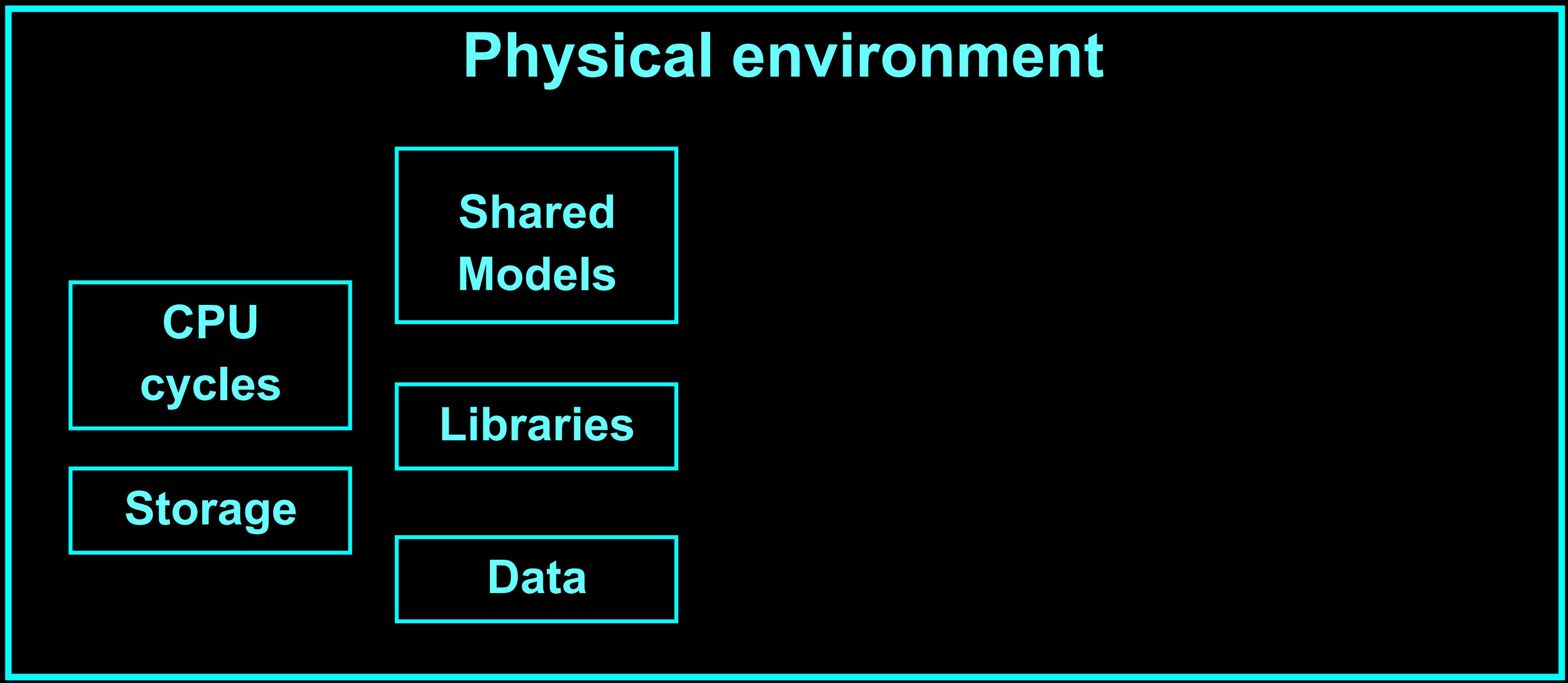
World Wide Web

❑ 1970s	Internet
❑ 1991	First website
❑ 1993	Mosaic web browser
❑ Late 90s	Mainstream commercialization
	Rapid growth of B2B
❑ 1999	Semantic web envisioned
❑ Now	Global infrastructure
	+ Wikipedia, Web 2.0…

Community modeling

"Collaborative approaches to problems that require contributions from the distributed community of modelers"

Virtual modeling environments



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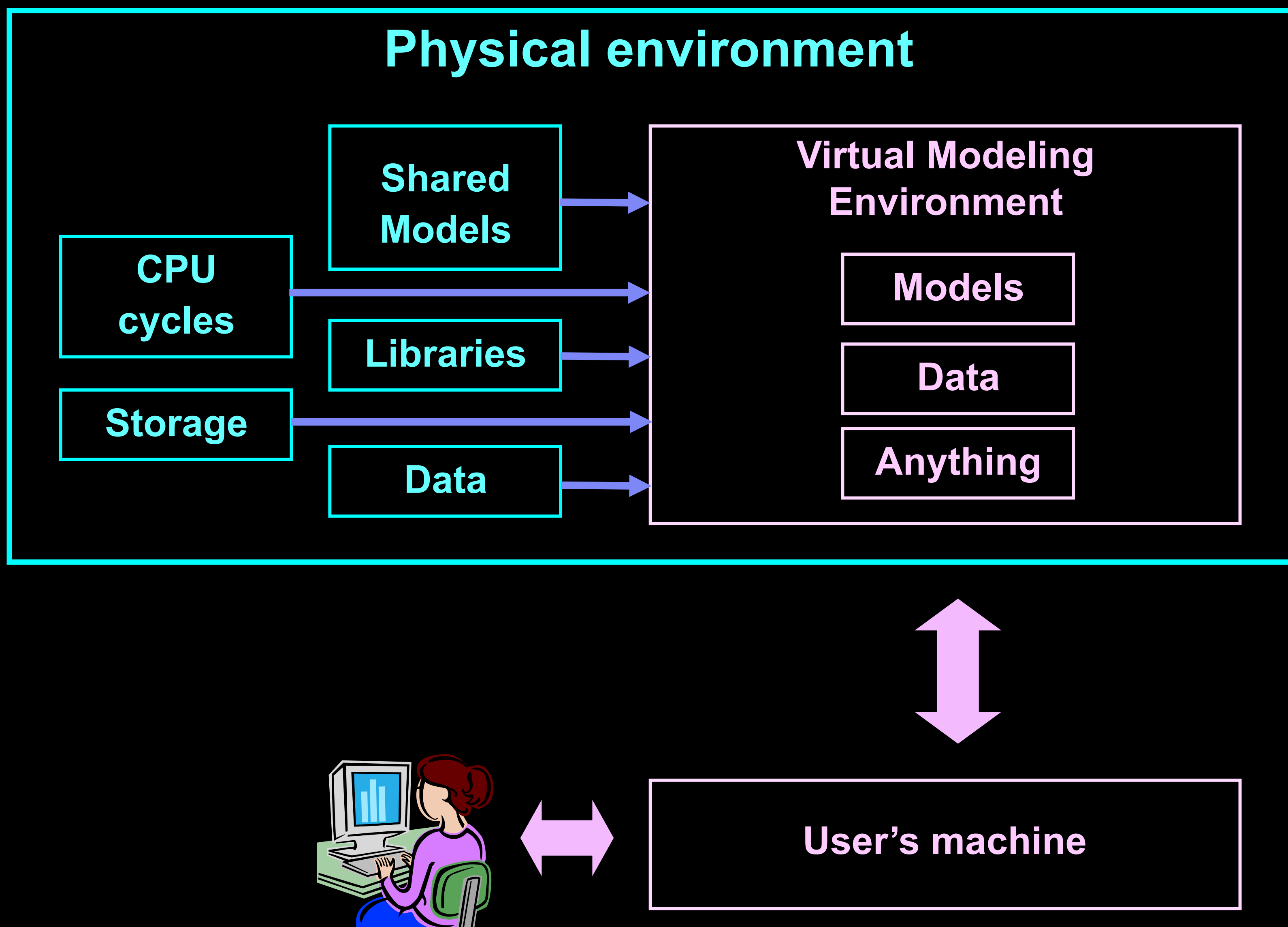


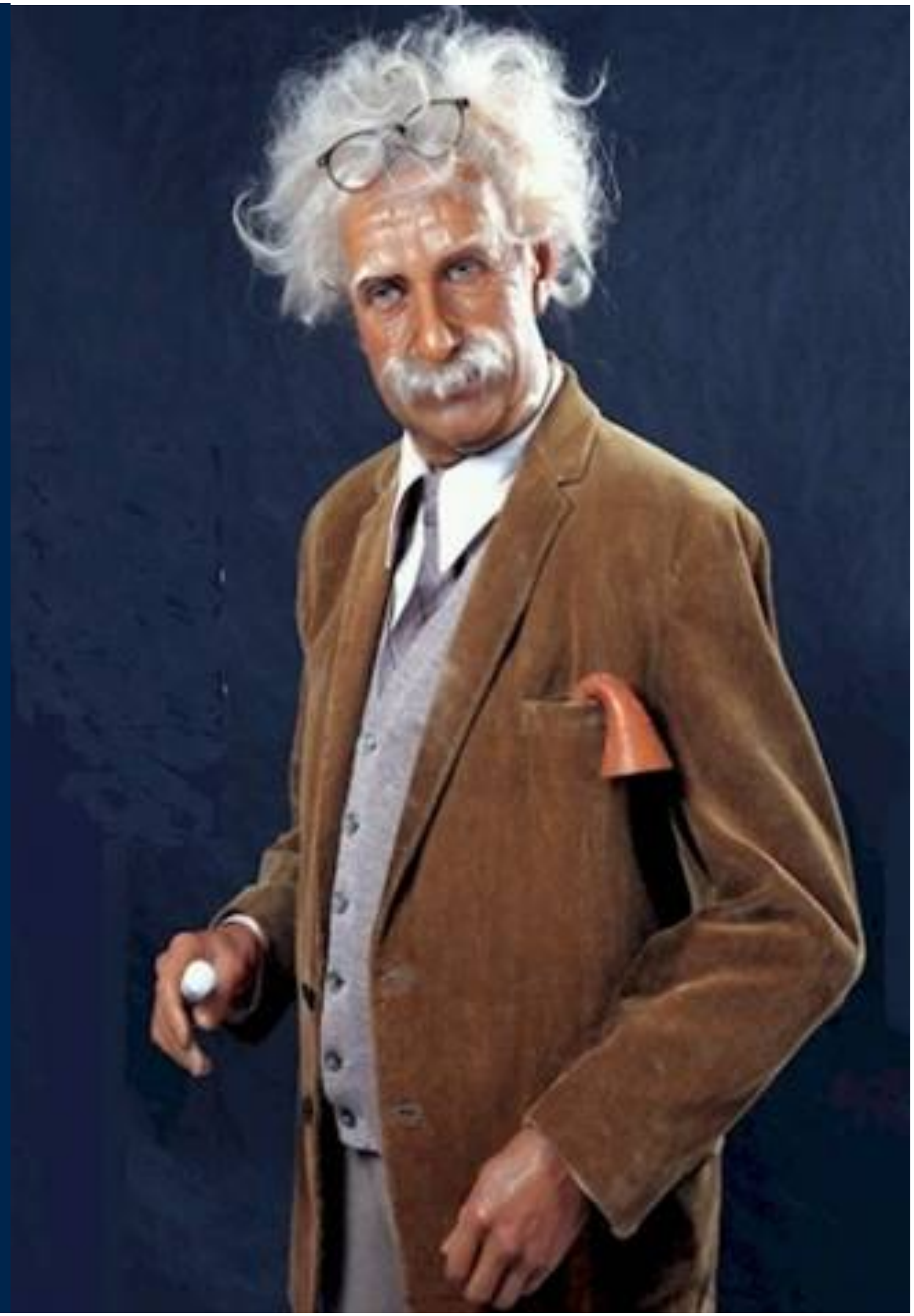
- Create new models

or

- Improve existing models

or

- Increase model interoperability and access



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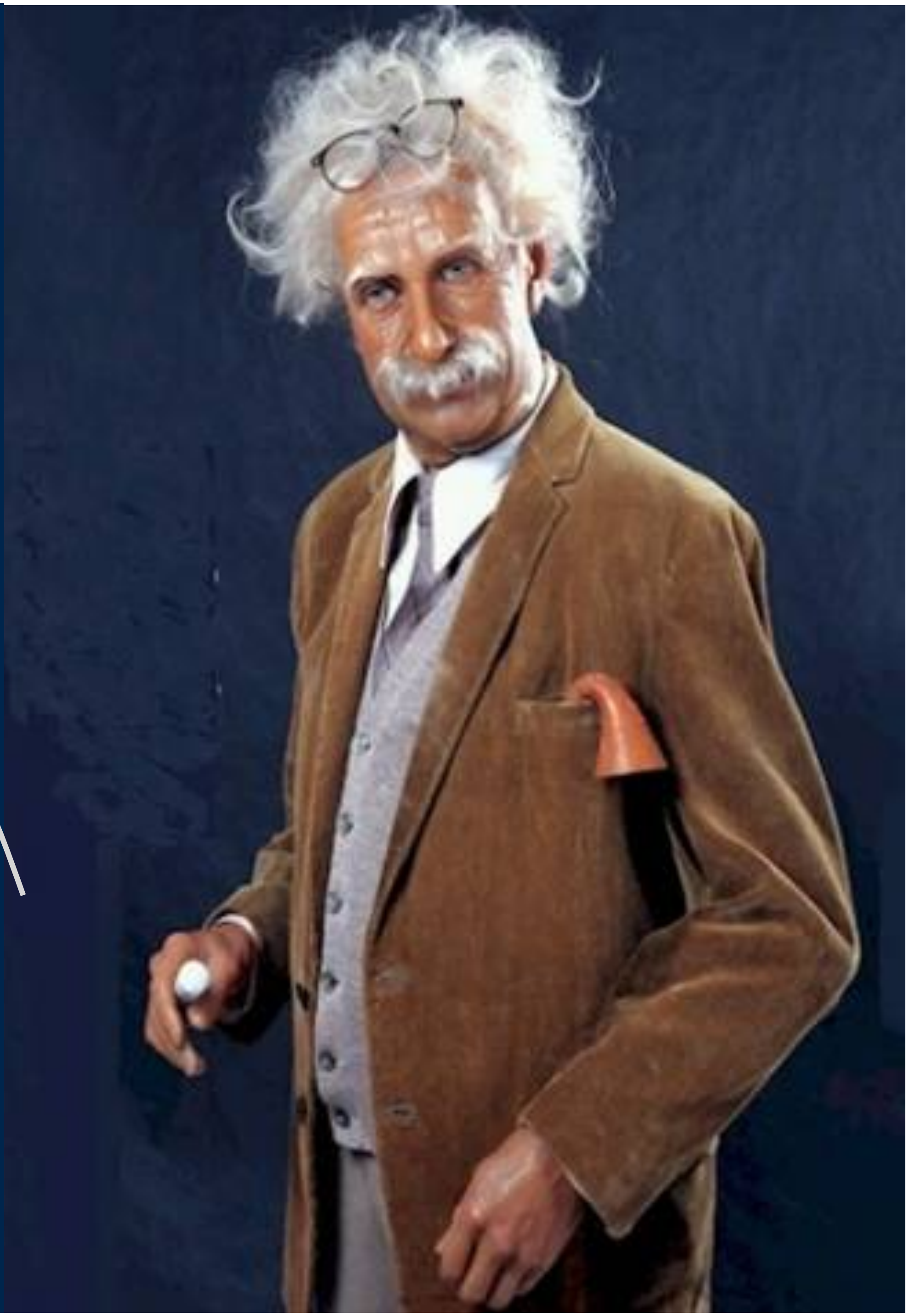
Model Web



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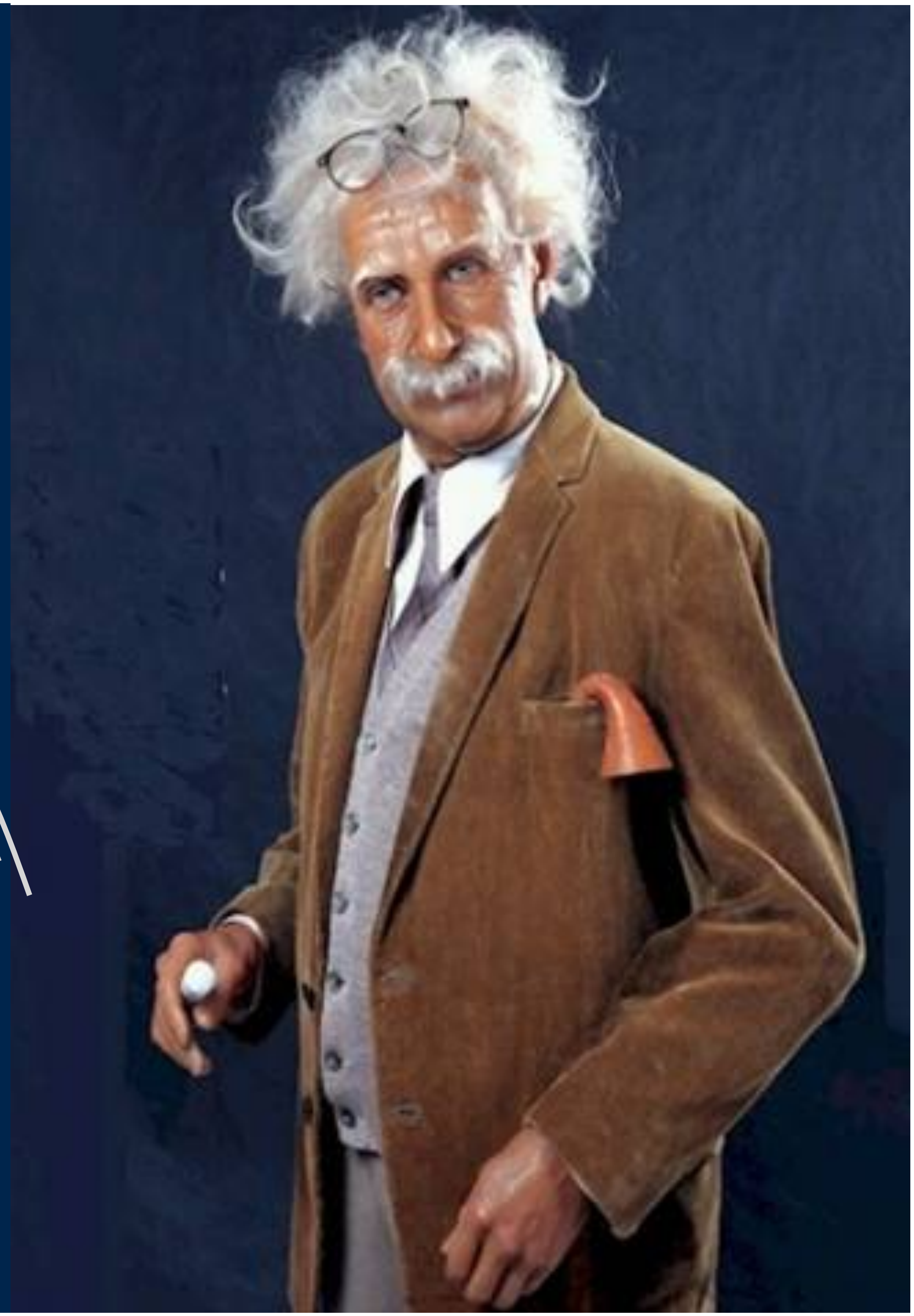
Model as a service → **Model Web**



Websites

- Critical component
- Connect people to information
- Audience-specific