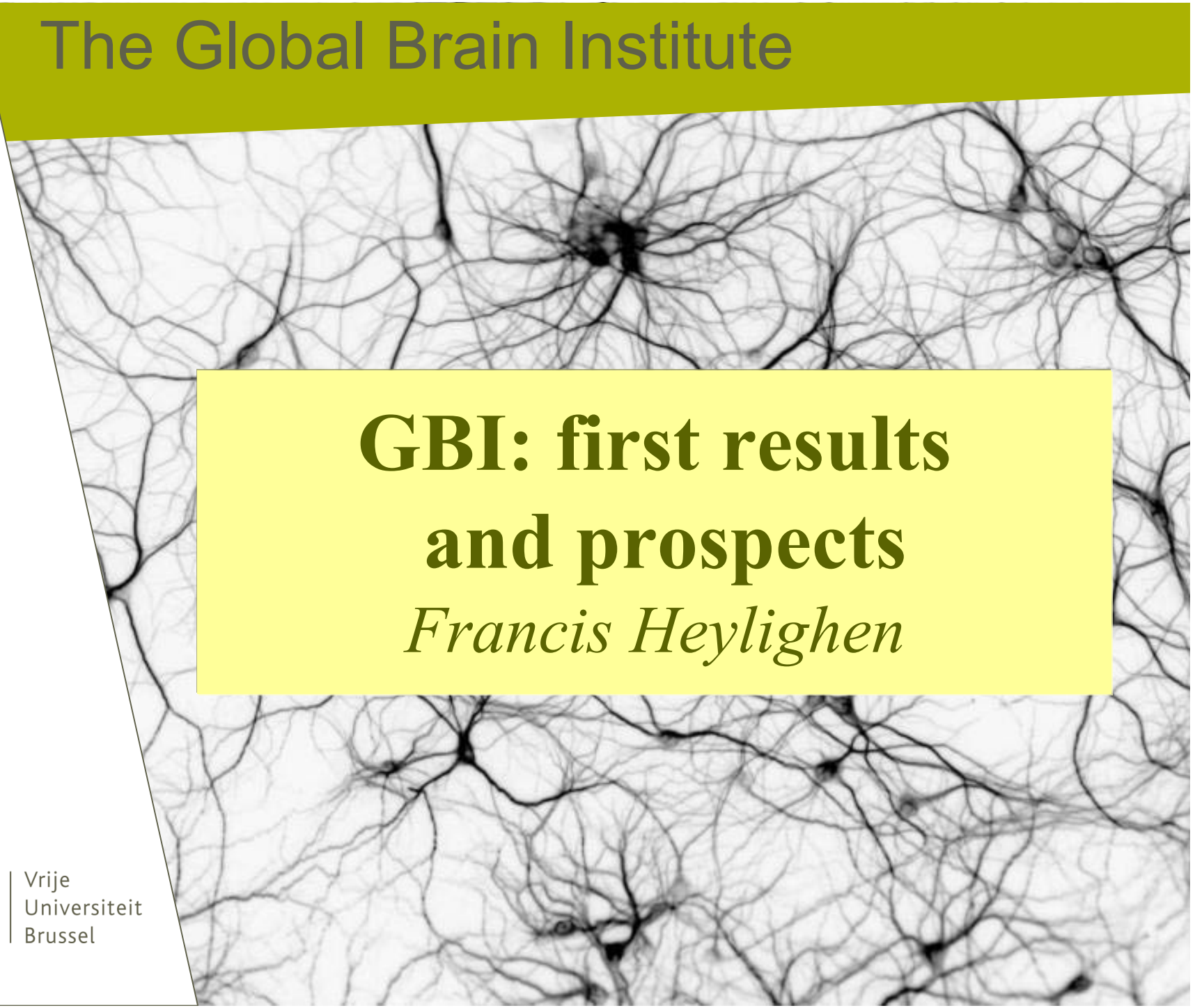
The Global Brain Institute



GBI: first results and prospects

Francis Heylighen

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What is the Global Brain?

- **Distributed Intelligence**
  - Ability to solve problems
  - Not centralized or localized in a single agent
  - Many agents contribute to the solutions
    - “society of mind”
  - Potentially much smarter than any individual intelligence
- **As emerging from the Internet**
  - People, machines, and software
  - Connected by a network of links
  - Extending globally

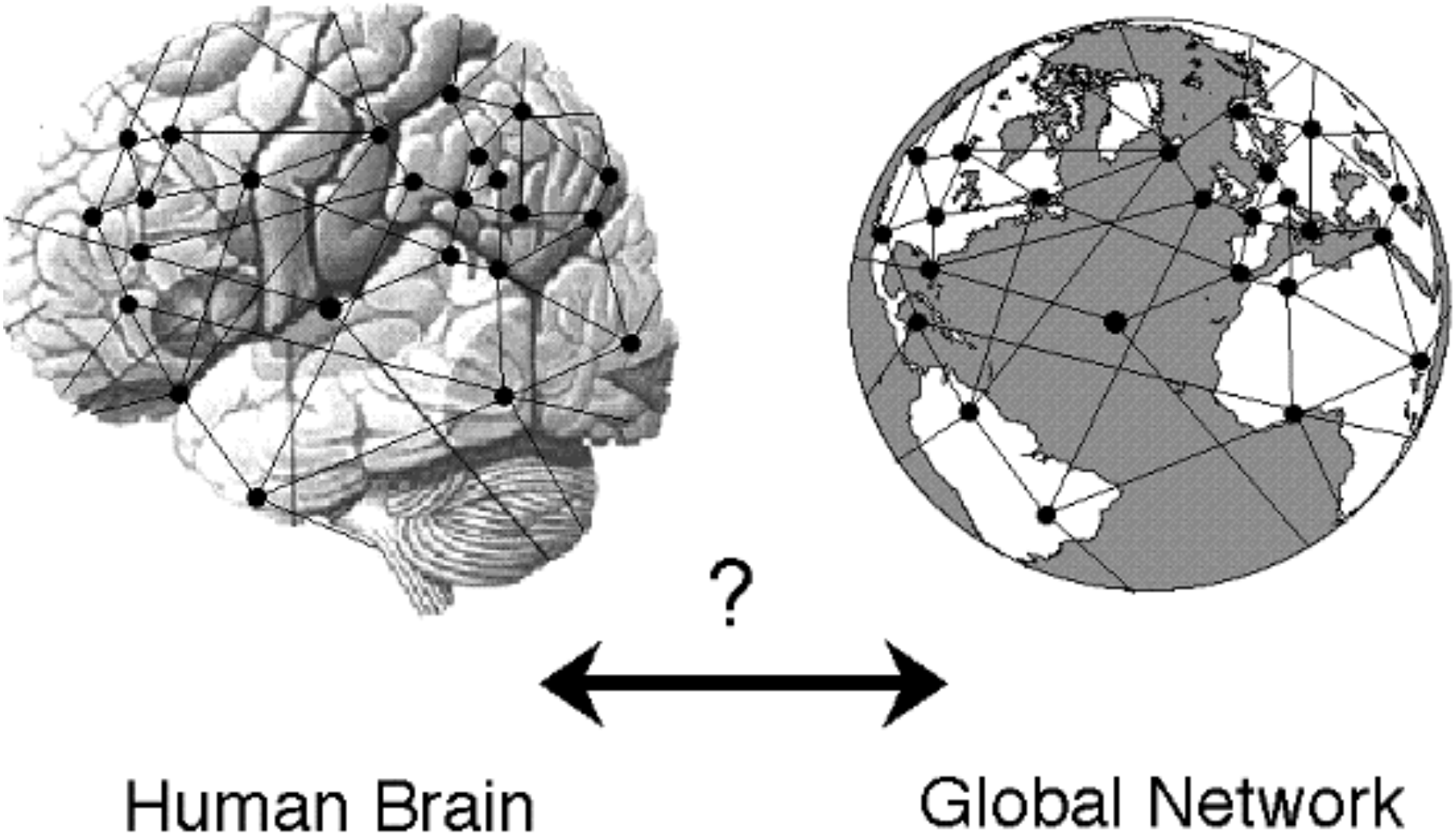
Global Networks

The Global Brain Institute (GBI)

- **Founded January 2012**
  - At the VUB
  - Director: Francis Heylighen
  - Main sponsor: Yuri Milner
    - Investor in social media: Facebook, Groupon, Twitter, etc.
- **Aim**
  - To develop a general theory of the Global Brain
  - Supported by a mathematical model

Prehistory

- **Global Brain Group**
  - Founded 1996 by Francis Heylighen and Ben Goertzel
  - International discussion forum
  - Grouping most active researchers in the domain
- **Organized first Global Brain Workshop**
  - VUB, July 3-5, 2001
- **Still maintains GBRAIN-L mailing list**


?
Human Brain
Global Network

Present GBI personnel

Researchers (with their education)

- **Eva Busseniers**: mathematics
- **Viktoras Veitas**: management, AI
- **Clément Vidal**: philosophy, cognitive science
- **David R. Weinbaum** ("Weaver"): computer engineering
- **Mixel Kiemen**: computer science, economics
- *Iavor Kostov* (not yet at VUB): engineering

GBI Scientific board

- **Johan Bollen** (Indiana University)
- **Joël de Rosnay** (Biotics International)
- **Cliff Joslyn** (Pacific Northwest National Laboratory)
- **Carlos Gershenson** (Universidad Nacional Autonoma de Mexico)
- **Ben Goertzel** (Singularity Institute for Artificial Intelligence)
- **Marko A. Rodriguez** (Aurelius LLC)
- ? Thomas Malone ? (invited, MIT)
- …?

Tools used by the GBI

- **Public website**
  - www.globalbraininstitute.org
  - People, publications, working papers, videos, newsfeed…
- **Private website**
  - intranet.globalbraininstitute.org
  - Work-in-progress, discussions, issue queue…
- **Private mailing list: gbi@listserv.vub.ac.be**
- **Shared bibliography (Zotero)**

GBI Working Papers

- **Preliminary reports on on-going research**
- **Heylighen F.**
  - The GBI Vision: past, present and future context of global brain research
  - Challenge Propagation: a new paradigm for modeling distributed intelligence
- **Weinbaum, D.**
  - A Framework for Scalable Cognition
- **Busseniers, E.**
  - Hierarchical organization vs. self-organization
- **Heylighen F., Kiemen M., & Kostov I.**
  - Mobilization Systems and the Stigmergic University

GBI Objectives

- **Develop a theory of the Global Brain**
- **Build mathematical model / simulation**
- **Survey relevant social/ICT developments**
- **Compare observations with**
  - implications of theory
  - simulation results
- **Investigate implications for the future**
- **Disseminate ideas towards the public**

The GBI view of intelligence

- **Intelligence = ability to deal with challenges**
  - *Challenge* = situation that invites action
    - Problem, opportunity, question, stimulus, idea, information…
  - Successful action improves situation for agent
    - Solves problem, exploits opportunity, …
  - High intelligence = high extraction of benefit
  - Intelligence requires
    - Selection of most important challenges
    - Selection of most appropriate actions

Distributed Intelligence

- **Individual agent has limited abilities/knowledge**
  - Cannot always recognize most important challenge
  - Cannot always select best action
  - Cannot always implement best action
- **Different agents have different skills**
  - The one may be able to do what the other cannot
- **Solution: *distributed* intelligence**
  - Different tasks performed by different agents
  - Results integrated into global solution

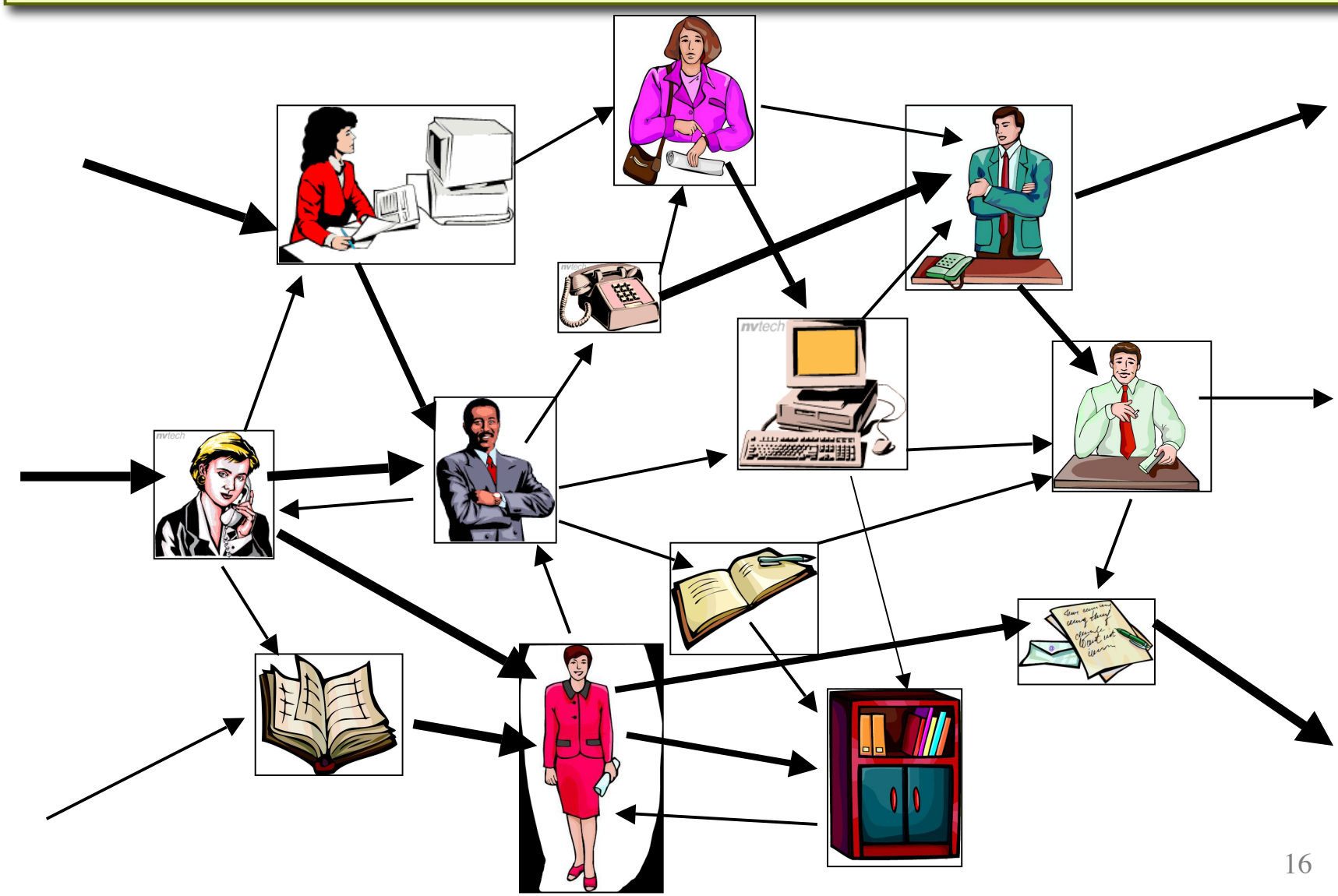
Origin of distributed intelligence

- **Guided: *mobilization systems***
  - Agents are stimulated or motivated to act
    - By presenting clear goals and feedback
  - System is organized so as to facilitate coordinated action
- **Spontaneous: *self-organization***
  - Challenges propagate across different agents
    - Until they are fully resolved
  - Links between agents adapt to use
    - Strengthening of useful links, weakening of others

Challenge Propagation

- **Each agent extracts the benefit it can get from the challenges it encounters**
- **Challenges that that still have benefit left are passed on to other agents**
  - In the agent's "(social) neighborhood"
  - So that they can extract more benefit
- **Thus, challenges propagate from agent to agent**
  - Generalization of "spreading activation" in a neural network

Propagation of Challenges



Examples

- **Question, observation, link, idea, opportunity…**
  - Emailed to friend(s)
  - Posted in discussion forum
  - Posted as Facebook “status update”
  - Distributed as “tweet”
  - Written down in wiki
- **Forwarded, reposted, retweeted … to others**
- **Elicits reactions, suggestions, corrections…**

Application: GBI issue queue

- **GBI researchers posts "issue" on intranet**
  - Problem or opportunity to advance
  - Demands action
    - E.g. read book, invite person, organize seminar,…
- **Other GBI researchers pick up the issue**
  - Either by spontaneously checking the queue
  - Or being warned about a relevant issue
- **Contribute to tackling it**
- **Until the problem is solved**

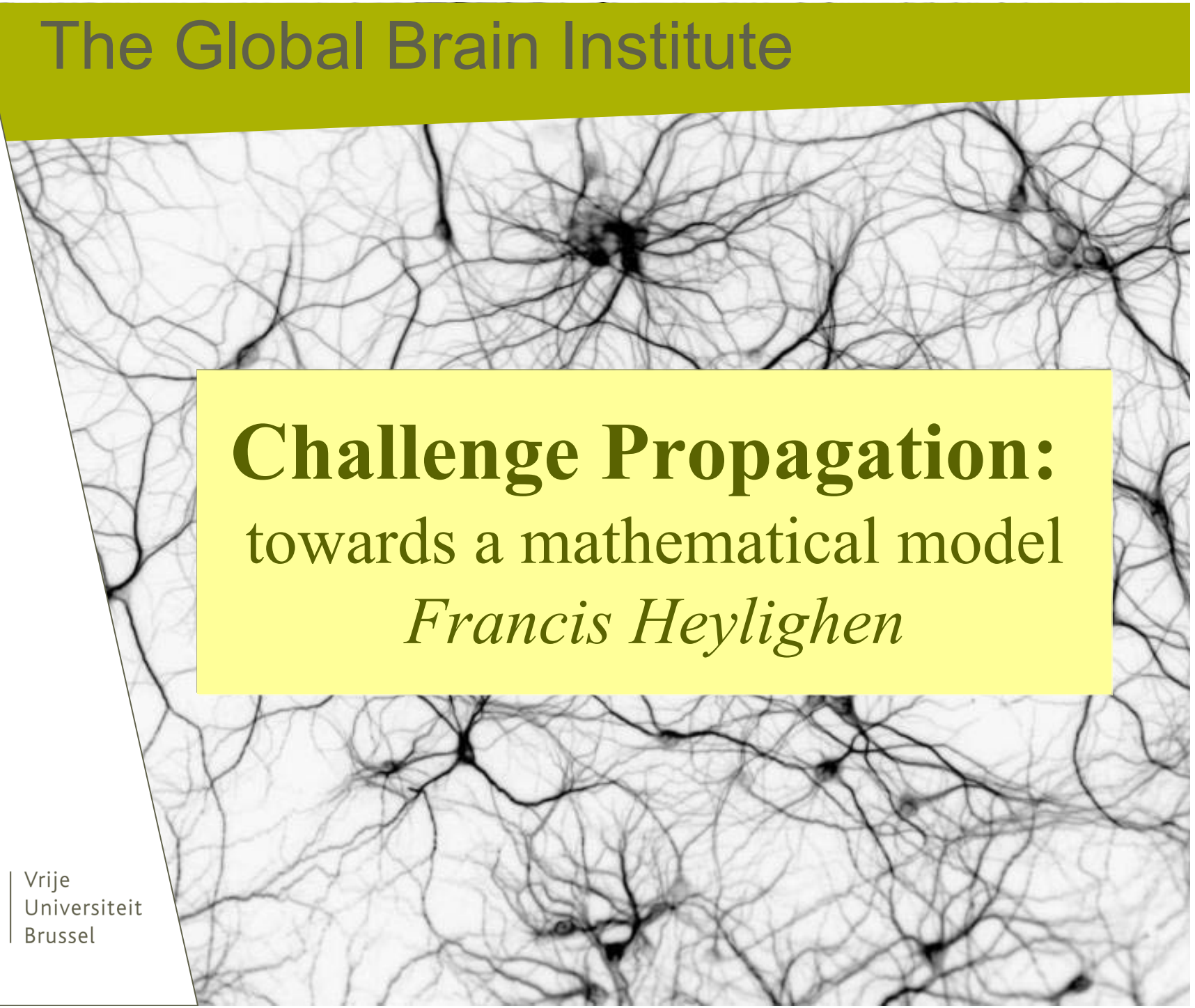
Application: GBI Newsfeed

- **People publish info on the web**
- **Filtering rules/volunteers extract potentially relevant ones**
  - Using keyword such as “global brain”, “collective intelligence”, etc.
  - Suggest them to “curator”
- **Curator selects most interesting ones**
- **Selected posts are published on GBI site**
  - Where readers may pick them up and forward them further

Any questions?

- **Theory and specific applications will be discussed in more detail later…**
- **Now is the time to discuss our general organization**

The Global Brain Institute



Challenge Propagation:
towards a mathematical model

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Basic concepts of the GB

- **Agents**: human or machine
  - Agents act on challenges
- **Challenges** : generalization of problems and opportunities
- **Intelligence**: ability to successfully tackle challenges
- **Distributed intelligence**: challenges tackled collaboratively by many agents working in parallel
  - Requires diversity of agents/skills/situations
  - Requires coordination of actions

The need for a mathematical model

- **We want to understand exactly how distributed intelligence operates**
- **So as to compare:**
  - Different propagation methods
    - E.g. email, Twitter, Facebook updates, wiki edits…
  - Different network topologies
  - Different agent abilities, …
- **In particular, to measure relative intelligence**
  - Allowing us to optimize existing systems

Restrictions of modeling

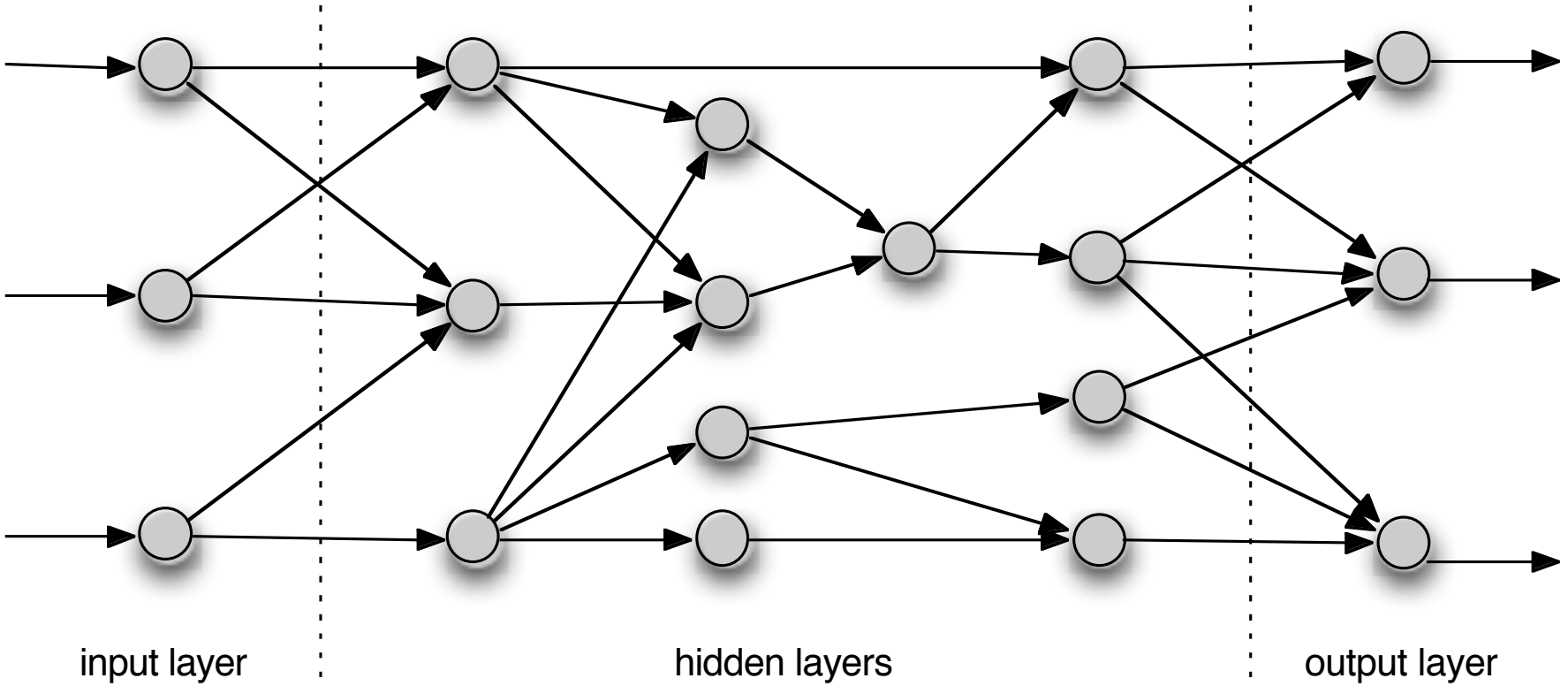
- **A model is always a simplification**
  - It needs to reduce an infinitely complex reality to a finite list of symbols and numbers
  - That are easy to manipulate
    - So as to compute different implications or forecasts
- **Yet, the model should try to maintain the essence of the theory**
  - While remaining flexible enough to accommodate new insights

Challenge propagation

- **Challenges propagate from agent to agent**
- **Following links in a network**
- **Challenges get “relaxed” while propagating**
  - Spreading activation dynamics
  - From “tension” to “equilibrium”
  - But the system as a whole remain far-from-equilibrium
  - Because new challenges are constantly generated

Neural Network Paradigm

- **Input activation vector = “challenge”**
- **Output activation vector = “solution”**



Challenges as vectors

- Situation vector: $\mathbf{s}$
  - List of numbers representing the present situation
  - E.g. $(4, 0, 0.3, 2.4, 7.23, \ldots)$
- Need vector: $\mathbf{g}_i$
  - List of numbers representing the ideal situation for a given agent a_i
- Challenge = difference between situation and need vectors

$$\mathbf{c}_i = \mathbf{s} - \mathbf{g}_i$$

Vector components

- **Numbers in the list represent "valences"**
  - Variables that potentially carry some value (positive or negative) for the agent
- **The need vector can also contain # symbols**
  - "don't care"
  - Representing a variable that is irrelevant for that agent
- **The situation vector can also contain ? symbols**
  - "don't know"
  - Representing a variable of which the agent does not know the value
- **Addition rules:**

$$\# + X = \#$$

$$? + X = X \quad (?)$$

Challenge Selection

- **Agents are confronted with many challenges**
- **They need to choose the most important ones to address**
- **Selection criteria**
  - Intensity of the challenge $\mathbf{c}$: $\| \mathbf{c} \| = \sqrt{\sum_{i=1}^{n} c_i^2} \geq 0$

    (# counts as 0 in the formula)

    (? counts as > 0, dependent on need variable?)
  - Ability of agent to tackle the challenge
  - Others?

Processing in the Agent

- An agent a performs a mapping from the initial challenge **c** to the processed challenge **c'** :

$$\mathbf{f}_a : \mathbb{R}^n \rightarrow \mathbb{R}^n : \mathbf{c} \rightarrow \mathbf{c'} = \mathbf{f}_a(\mathbf{c})$$

Agents can be programmed using various formalisms

  - Neural networks, production rules, heuristic search...

- **Different agents perform different processes**

Challenge relaxation

- **The agent tries to bring the present situation closer to the desired one**
  - by transforming the challenge vector: $c \rightarrow c'$
    - Tackle the problem
    - Exploit the opportunity
- **Ideally, the challenge vector is reduced to zero**

$$\mathbf{c' = s' - g' = 0}$$

- **Practically, the agent only extracts partial benefit from the challenge:**

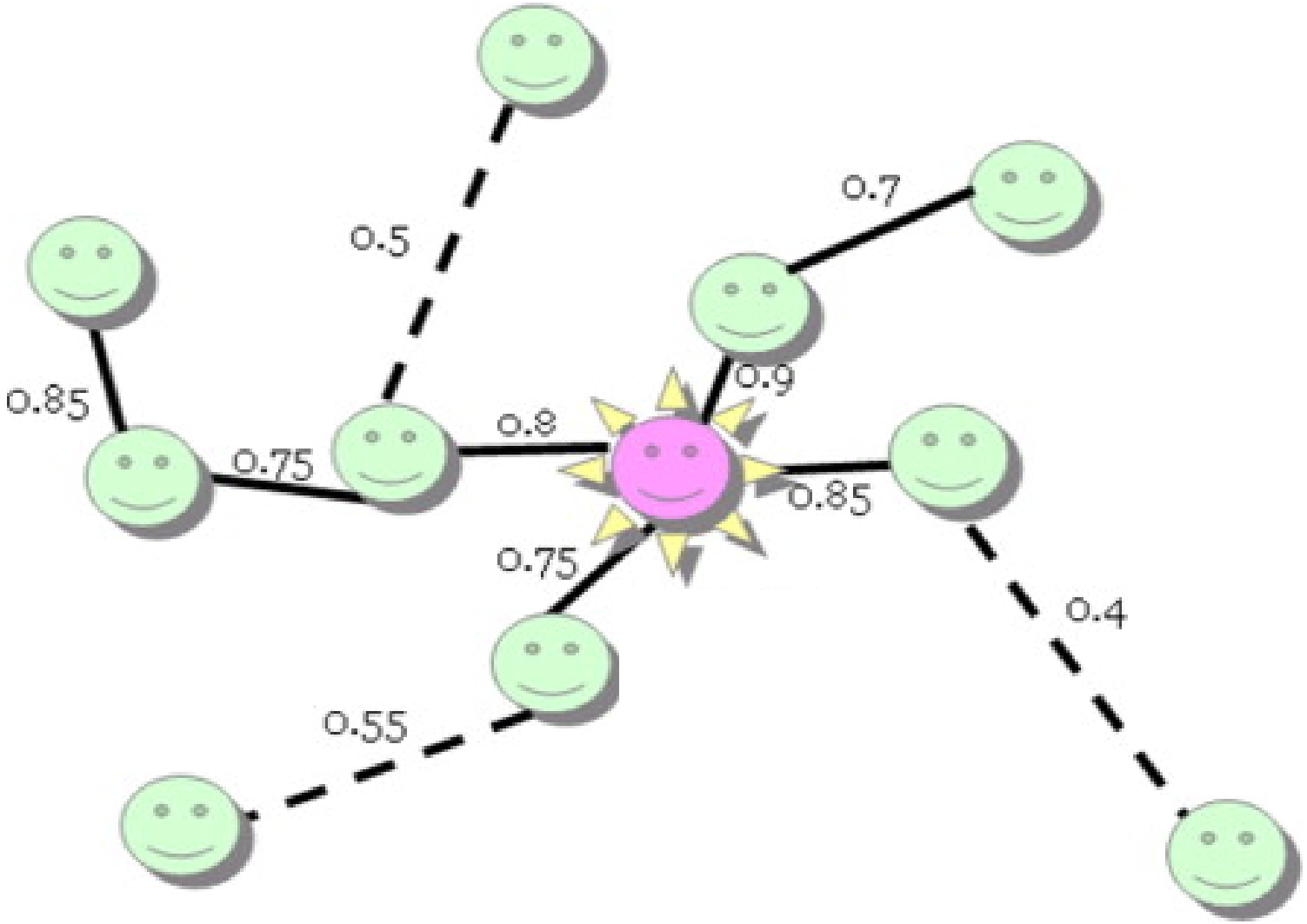
$$\mathbf{c' \neq 0}$$

Benefit = $\| \mathbf{c} \| - \| \mathbf{c'} \| \leq \| \mathbf{c} \|$

Challenge propagation

- **A processed challenge can be passed on to one or more connected agents**
- **These agents can decide to further process the challenge**
  - Depending on link strength and challenge intensity
- **And pass it on their connections**
  - Thus, it spreads continuously throughout the network
- **The process continues as long as there remains benefit to be extracted from the challenge**

Challenge Propagation



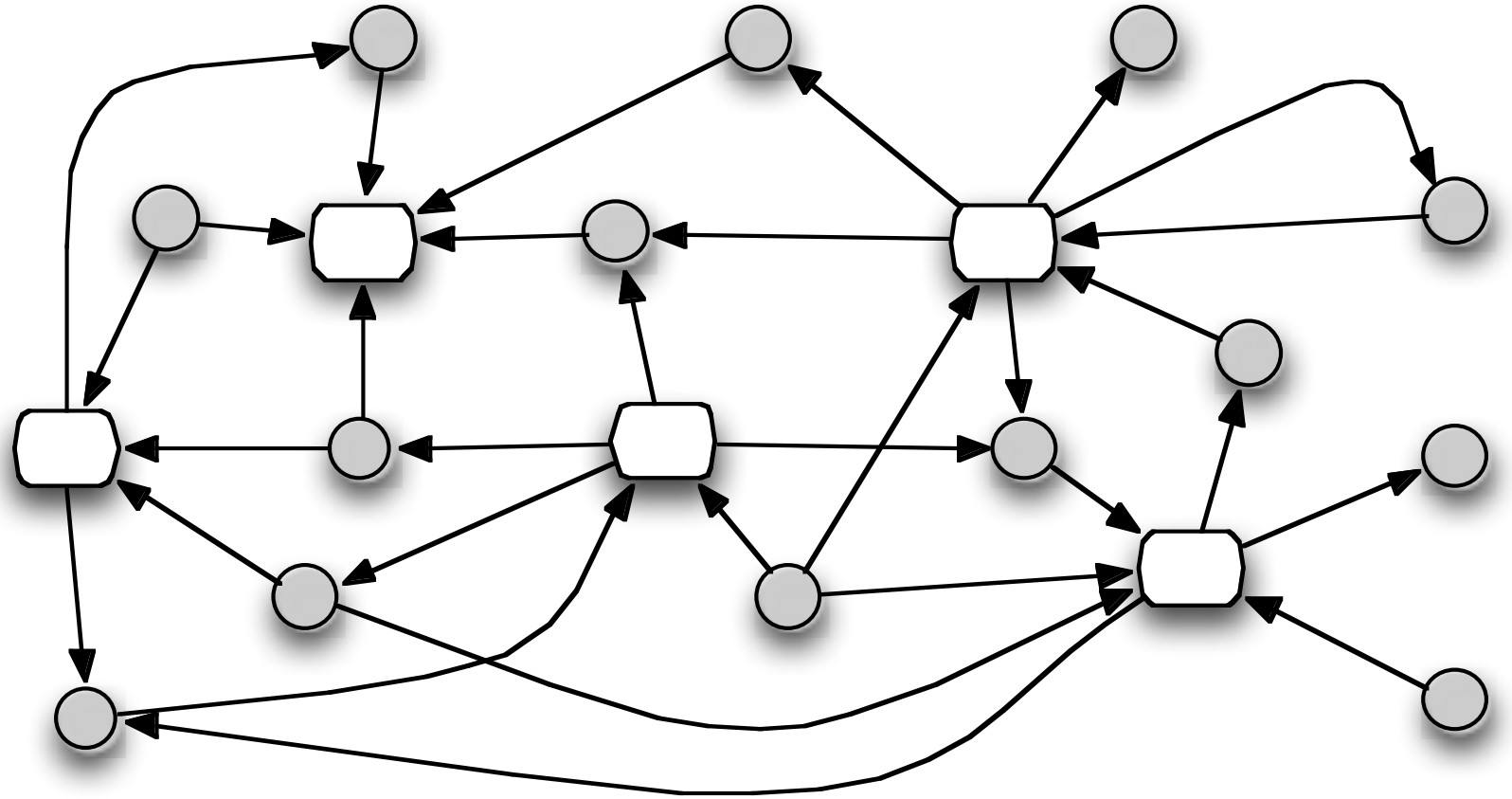
Relaxation Process

- **Challenge propagation is similar to a physical process of "relaxation"**
  - A disequilibrium or tension is gradually reduced
    - Potential Energy Gradient = Force
- **Examples**
  - Potential difference produces electrical current
  - Propagation of action potential in the brain
  - A wave spreading in water or air from the place of disturbance

The Learning Network

- **Challenges propagate via "multilinks"**
  - Conduits that connect two or more agents
  - E.g. social relationship or forum
- **Agents + multilinks form network**
  - Generalization of social network
  - Links have different weights, representing reliability of connection
- **Network adapts to propagation**
  - Successful links are strengthened
    - E.g. friendship or collaboration
  - Unsuccessful ones are weakened or eliminated
- **Thus, the network "learns"**
  - Increases distributed intelligence

Network with multilinks



Measuring Distributed Intelligence

- **Intelligence I = success in extracting benefit from challenges**
  - Individual intelligence = average benefit for one agent
  - Distributed intelligence = average benefit for agent collective

$$I = \frac{1}{n}\sum_{i=1}^{n}\left(\left\|\mathbf{c}_i\right\| - \left\|\mathbf{f}_a(\mathbf{c}_i)\right\|\right)$$

  - calculated on the basis of a finite (but large) sample of randomly generated challenges: $\{\mathbf{c}_1, \mathbf{c}_2, \ldots \mathbf{c}_n\}$
- Depends on: **agent abilities, network topology, propagation dynamics, selection criteria…**

The next step

- **Building a simulation**
  - Agents with specific processing abilities
  - Connected by multilink network
  - Random generation of challenge vectors
  - Letting agents select, process and propagate challenges
  - Measuring distributed intelligence of system
- **Trying out many different variations of these elements**
  - So as to see which works best