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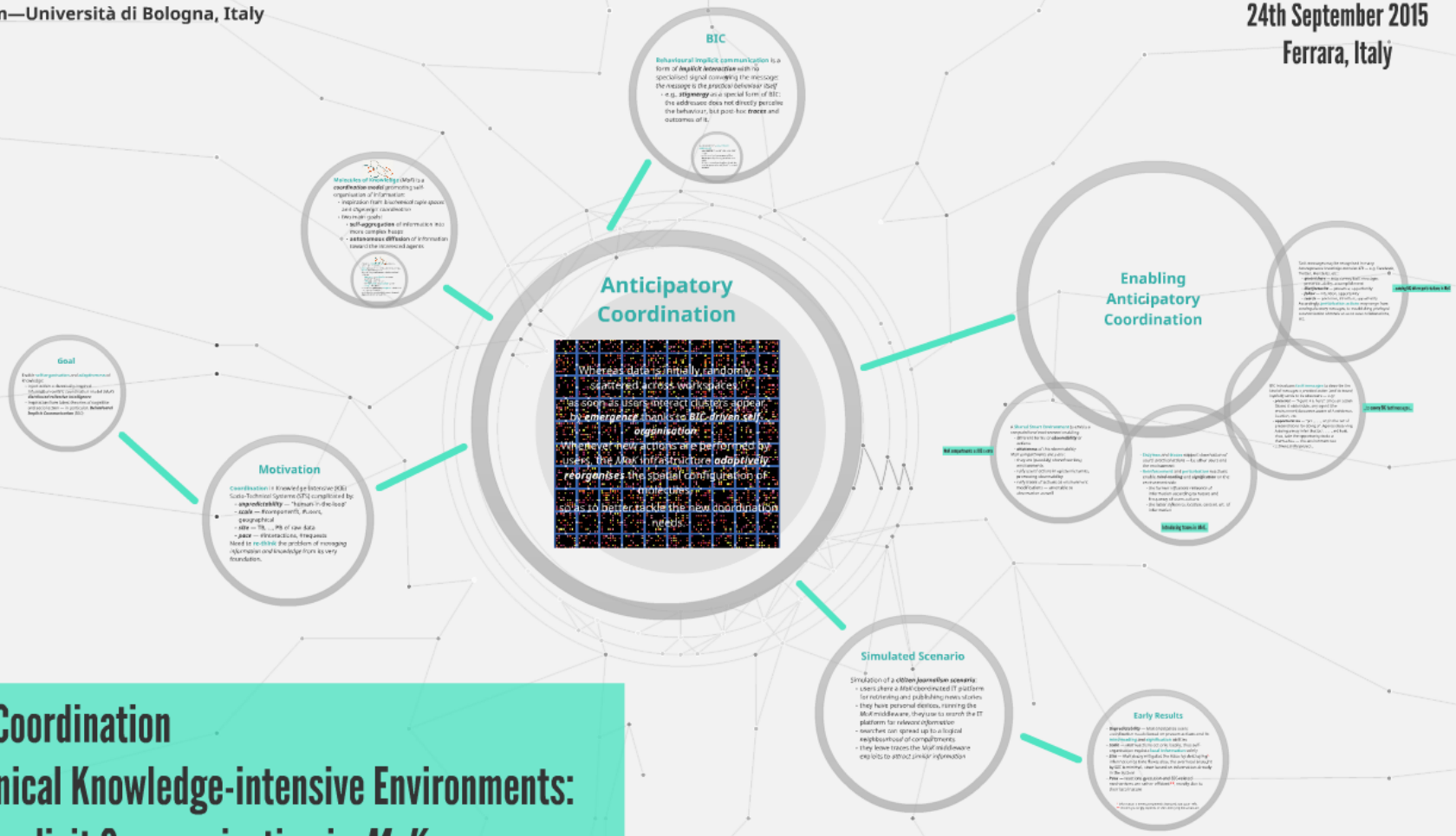
Alma Mater Studiorum—Università di Bologna, Italy

AIxIA 2015
24th September 2015
Ferrara, Italy

Anticipatory Coordination in Socio-technical Knowledge-intensive Environments: Behavioural Implicit Communication in *MoK*



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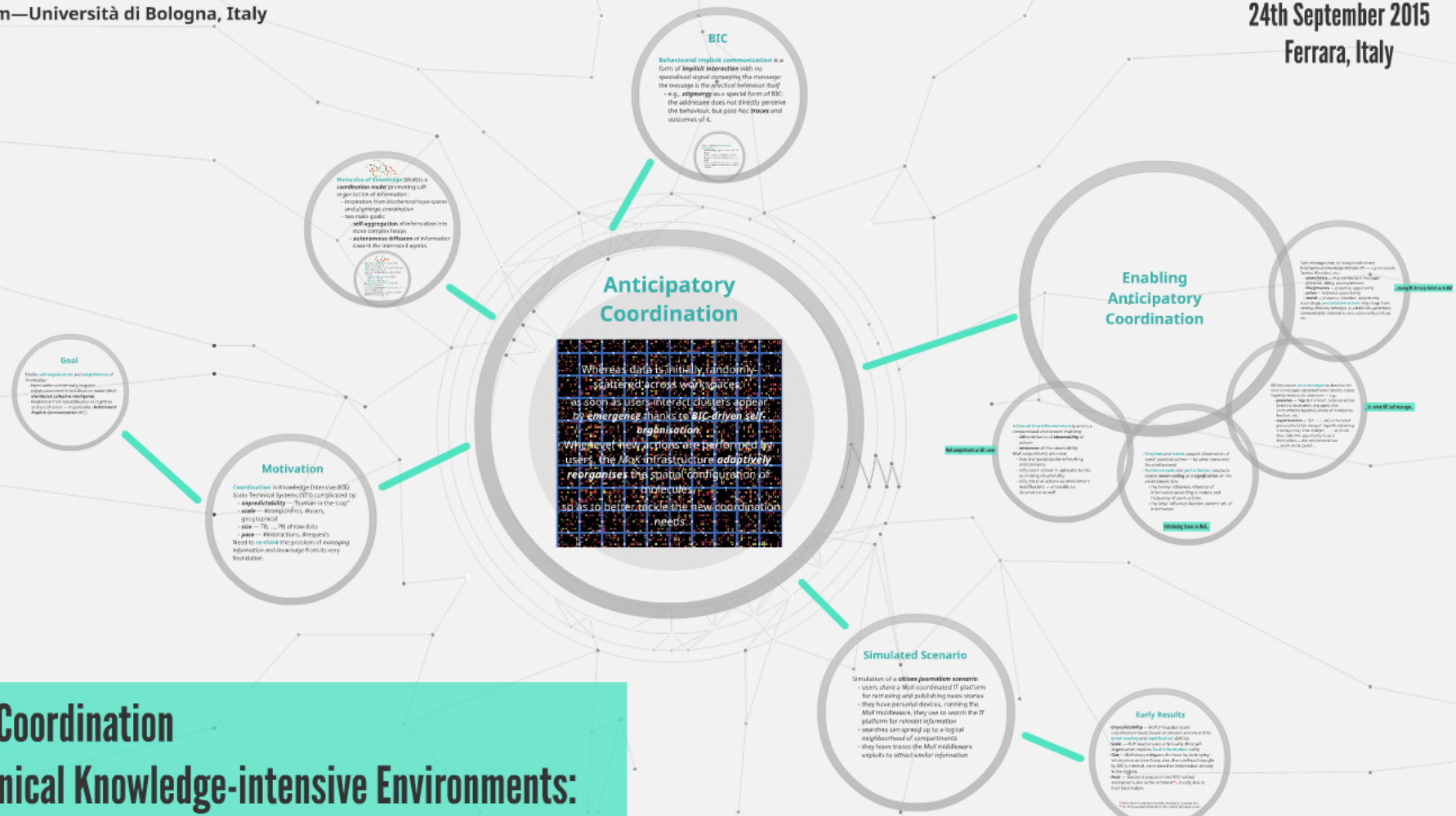
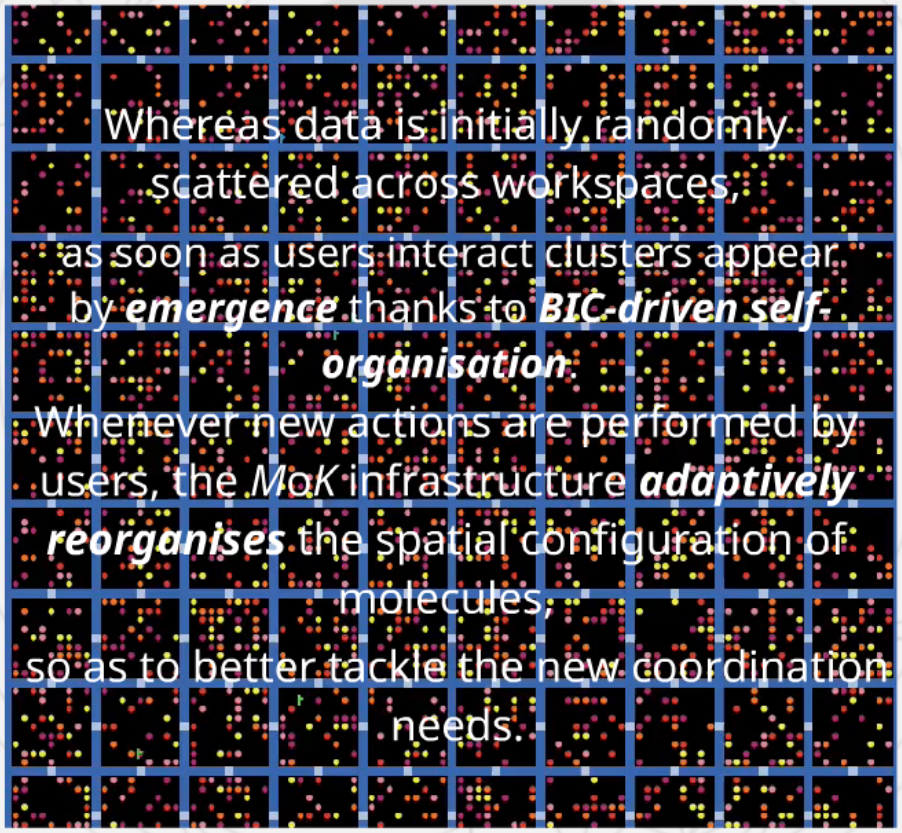


Anticipatory Coordination



Motivation

Coordination in Knowledge-Intensive (KIE) Socio-Technical Systems (STS) complicated by:

- ***unpredictability*** — "human-in-the-loop"
- ***scale*** — #components, #users, geographical
- ***size*** — TB, ..., PB of raw data
- ***pace*** — #interactions, #requests

Need to **re-think** the problem of *managing information and knowledge* from its very foundation.

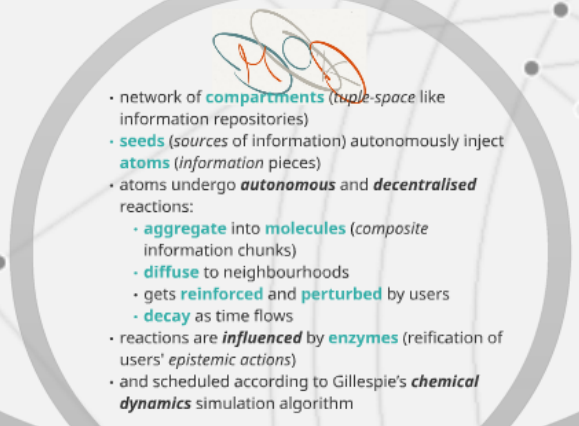
Goal

Enable **self-organisation** and **adaptiveness** of knowledge:

- inject within a chemically-inspired information-centric coordination model (*MoK*) ***distributed collective intelligence***
- inspiration from latest theories of cognitive and social action — in particular, ***Behavioural Implicit Communication*** (BIC)

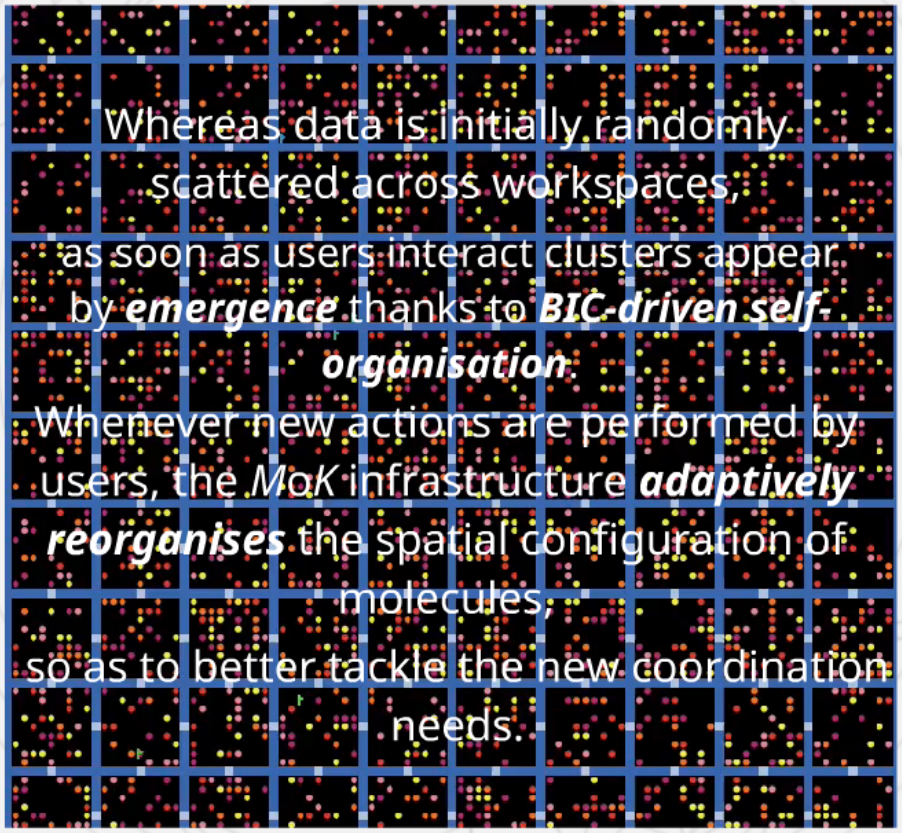
Molecules of Knowledge (*MoK*) is a ***coordination model*** promoting self-organisation of information:

- inspiration from *biochemical tuple spaces* and *stigmergic coordination*
- two main goals:
  - **self-aggregation** of information into more complex heaps
  - **autonomous diffusion** of information toward the interested agents



- network of **compartments** (*tuple-space* like information repositories)
- **seeds** (*sources* of information) autonomously inject **atoms** (*information* pieces)
- atoms undergo ***autonomous*** and ***decentralised*** reactions:
  - **aggregate** into **molecules** (*composite* information chunks)
  - **diffuse** to neighbourhoods
  - gets **reinforced** and **perturbed** by users
  - **decay** as time flows
- reactions are ***influenced*** by **enzymes** (reification of users' *epistemic actions*)
- and scheduled according to Gillespie's ***chemical dynamics*** simulation algorithm

Anticipatory Coordination



BIC

Behavioural implicit communication is a form of ***implicit interaction*** with no specialised signal conveying the message: *the message is the practical behaviour itself*

- e.g., ***stigmergy*** as a special form of BIC: the addressee does not directly perceive the behaviour, but post-hoc ***traces*** and outcomes of it.

Requirements for a **computational environment**:

- ***observability*** of agents' actions and their traces
- ability to *understand* ***actions*** *and their* ***traces***, possibly inferring intentions and goals
- ability to *understand the effects of activities*, so as to opportunistically obtain a desired ***reaction***

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Enabling Anticipatory Coordination

A **Shared Smart Environment** (s-env) is a *computational environment* enabling:

- different forms of ***observability*** of

Tacit messages may be rec
heterogeneous knowledge i
Twitter, Mendeley, etc.:

- ***quote/share*** — may co
  presence, ability, accom
- ***like/favourite*** — preser
- ***follow*** — intention, opp
- ***search*** — presence, inte

Accordingly, **perturbation**
sending discovery messages
communication channels so
etc.

BIC introduces **tacit messages** to describe
kind of *messages a practical action (and its tr*
implicitly sends to its observers — e.g.:

- ***presence*** — "Agent *A* is here". Since an a
  (trace) is observable, any agent (the
  environment) becomes aware of *A* existe
  location, etc.
- **opportunities** — "[*e1* , . . . , *en*] is the set
  preconditions for doing *a*". Agents obser
  A doing *a* may infer that [*e1* , . . . , *en*] hol
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  themselves — the environment too

ments as BIC s-envs

A **Shared Smart Environment** (s-env) is a *computational environment* enabling:

- different forms of ***observability*** of actions
- ***awareness*** of this observability

MoK compartments are s-env:

- they are (possibly) *shared* working environments
- reify users' *actions* in epistemic terms, promoting observability
- reify *traces* of actions as environment modifications — amenable to observation as well

- **Enzyme**
  users' *p*
  the envi
- **Reinfor**
  enable *r*
  environ
  - the f
    infor
    frequ
  - the l
    infor

- **Enzymes** and **traces** support observation of users' *practical actions* — by other users and the environment
- **Reinforcement** and **perturbation** reactions enable ***mind-reading*** and ***signification*** on the environment side
  - the former *influences relevance* of information according to nature and frequency of users actions
  - the latter *influences location, content, etc.* of information

Introducing traces in *MoK*...

BIC introduces **tacit messages** to describe the kind of *messages a practical action (and its traces) implicitly sends* to its observers — e.g.:

- ***presence*** — "Agent *A* is here". Since an action (trace) is observable, any agent (the environment) becomes aware of *A* existence, location, etc.
- **opportunities** — "[*e1* , . . . , *en*] is the set of preconditions for doing *a*". Agents observing *A* doing *a* may infer that [*e1* , . . . , *en*] hold, thus, take the opportunity to do *a* themselves — the environment too
- *... [more in the paper] ...*

...to convey BIC tac

observation of
other users and

ation reactions
nification on the

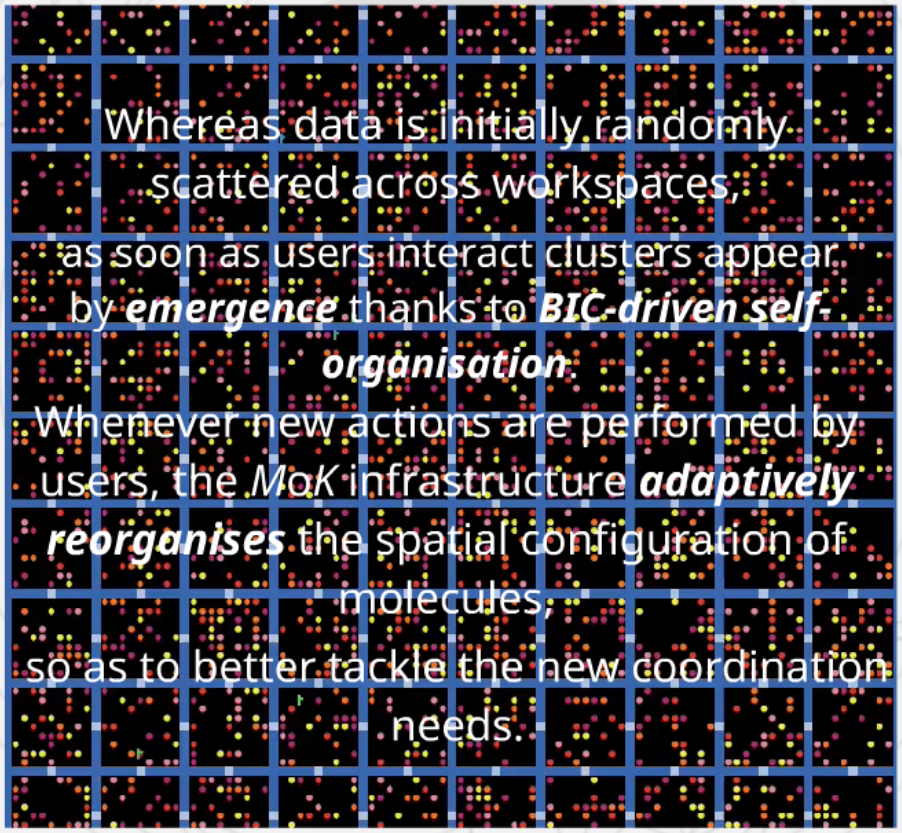
Tacit messages may be recognised in many *heterogeneous knowledge intensive STS* — e.g. Facebook, Twitter, Mendeley, etc.:

- ***quote/share*** — may convey tacit messages presence, ability, accomplishment
- ***like/favourite*** — presence, opportunity
- ***follow*** — intention, opportunity
- ***search*** — presence, intention, opportunity

Accordingly, **perturbation actions** may range from *sending discovery messages*, to establishing *privileged communication channels* so as to ease collaborations, etc.

...causing BIC-driven perturbat

Anticipatory Coordination



Simulated Scenario

Simulation of a ***citizen journalism scenario***:

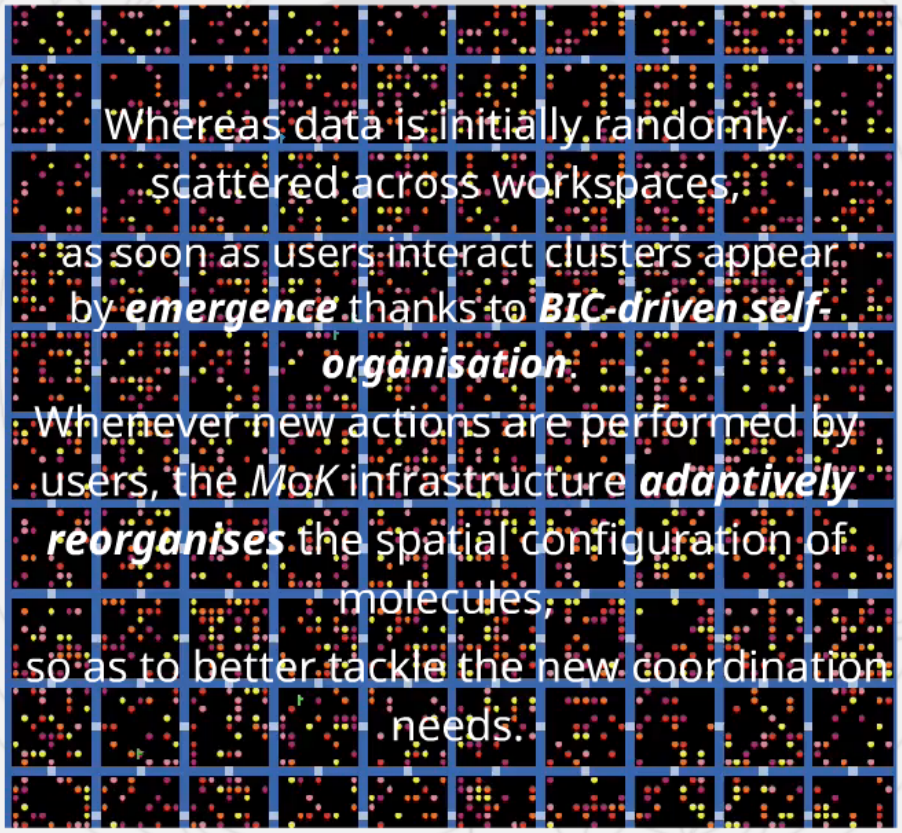
- users *share* a *MoK*-coordinated IT platform for retrieving and publishing news stories
- they have personal devices, running the *MoK* middleware, they use to *search* the IT platform for *relevant information*
- searches can spread up to a logical *neighbourhood* of compartments
- they leave traces the *MoK* middleware exploits to *attract similar information*

Early Results

- ***Unpredictability*** — *MoK* anticipates users coordination needs based on present actions and its **mind-reading** and **signification** abilities
- ***Scale*** — *MoK* reactions act only locally, thus self-organisation exploits **local information** solely
- ***Size*** — *MoK* decay mitigates the issue by destroying* information as time flows; also, the overhead brought by BIC is minimal, since based on information already in the system
- ***Pace*** — reactions execution and BIC-related mechanisms are rather efficient**, mostly due to their local nature

* information is never permanently destroyed, see paper refs.
** efficiency strongly depends on the underlying infrastructure

Anticipatory Coordination



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