



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

**Anticipatory  
 Coordination**



**BIC**

Behavioural implicit communication is a form of implicit interaction with no explicit signal conveying the message for usage in the practical situation itself.  
 e.g. *stereotype* as a special form of BIC: the address does not directly generate the behaviour, but point to them and influence it.

**Modulus of Knowledge (MoK)**

Modulus of Knowledge (MoK) is a construct used to describe self-organizing state of the environment. It is a complex of:
 

- interaction force, behavioural aspects and cognitive configuration
- emergence goals
- self-organization of information into some cognitive maps
- emergence of a field of information around the concerned agents

**Goal**

Goal is self-organization and adjustment of knowledge.
 

- emergent force through cognitive interaction
- self-organization of MoK
- emergence from base structure of cognitive and goal states
- emergent force through cognitive interaction

**Motivation**

Coordination in Knowledge-intensive (KI) Socio-Technical Systems (STS) can be described by:
 

- *spontaneity* — bottom-up process
- *scale* — response, space, geographical
- *size* — 10% of raw data
- *goal* — emergence, emergence

 Need to re-define the problem of conveying information and knowledge from its very foundation.

**Enabling  
 Anticipatory Coordination**

Self-organization and emergence in social systems.
 

- emergence from base structure of cognitive and goal states
- emergent force through cognitive interaction
- self-organization of MoK
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- emergent force through cognitive interaction

**Simulated Scenario**

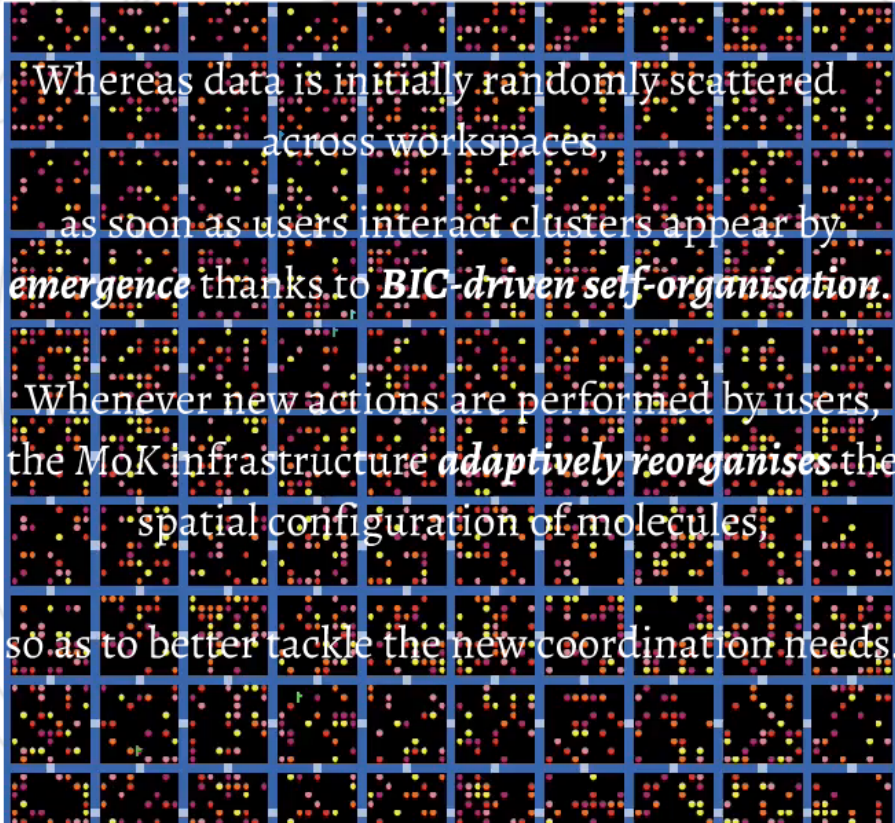
- simulation of a *diffuse innovation scenario*
- users share a MoK-coordinated IT platform for reviewing and publishing news items
- they have personal devices, running the MoK middleware, that use to search the IT platform for relevant information
- search can spread on a logical neighborhood of correspondences
- they leave traces the MoK middleware exploits to attract similar information

**Early Results**

Experimentation: that emerges are new information.
 

- emergent force through cognitive interaction
- self-organization of MoK
- emergence from base structure of cognitive and goal states
- emergent force through cognitive interaction

# Anticipatory Coordination



Whereas data is initially randomly scattered across workspaces,  
as soon as users interact clusters appear by *emergence* thanks to *BIC-driven self-organisation*.  
Whenever new actions are performed by users, the MoK infrastructure *adaptively reorganises* the spatial configuration of molecules,  
so as to better tackle the new coordination needs



# 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

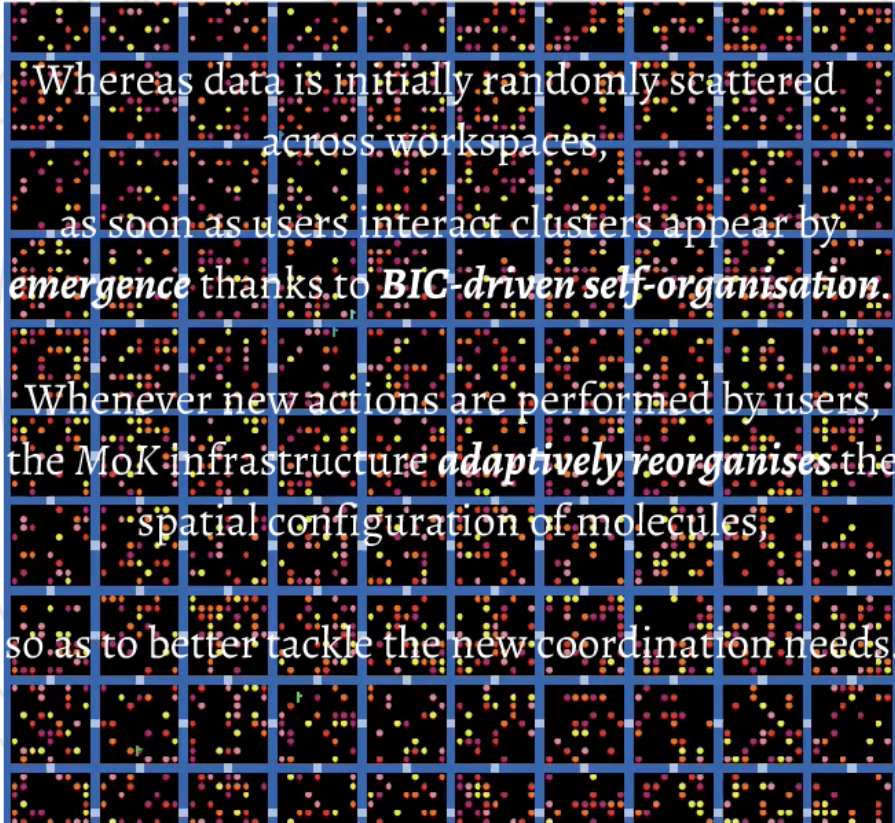


- network of **compartments** (*tuple-space* like information repositories)
- **seeds** (*sources* of information) autonomously inject **atoms** (*information* pieces)
- atoms undergo **autonomous** and **decentralised** reactions:
  - **aggregate** into **molecules** (*composite* information chunks)
  - **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

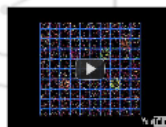


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Whenever new actions are performed by users, the MoK infrastructure *adaptively reorganises* the spatial configuration of molecules,  
so as to better tackle the new coordination needs





# 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 actions

Tacit messages may be recognized in *knowledge intensive STS* — e.g. I

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

Accordingly, **perturbation actions** send *discovery messages*, to establish *channels* so as to ease collaboration

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

- **presence** — “Agent A is here”. Since an action is observable, any agent (the environment) becomes aware of A existence, location, etc.
- **opportunities** — “[ $e_1, \dots, e_n$ ]” is the set of preconditions for doing *a*. Agents observing doing *a* may infer that [ $e_1, \dots, e_n$ ] hold, thus the opportunity to do *a* themselves — the

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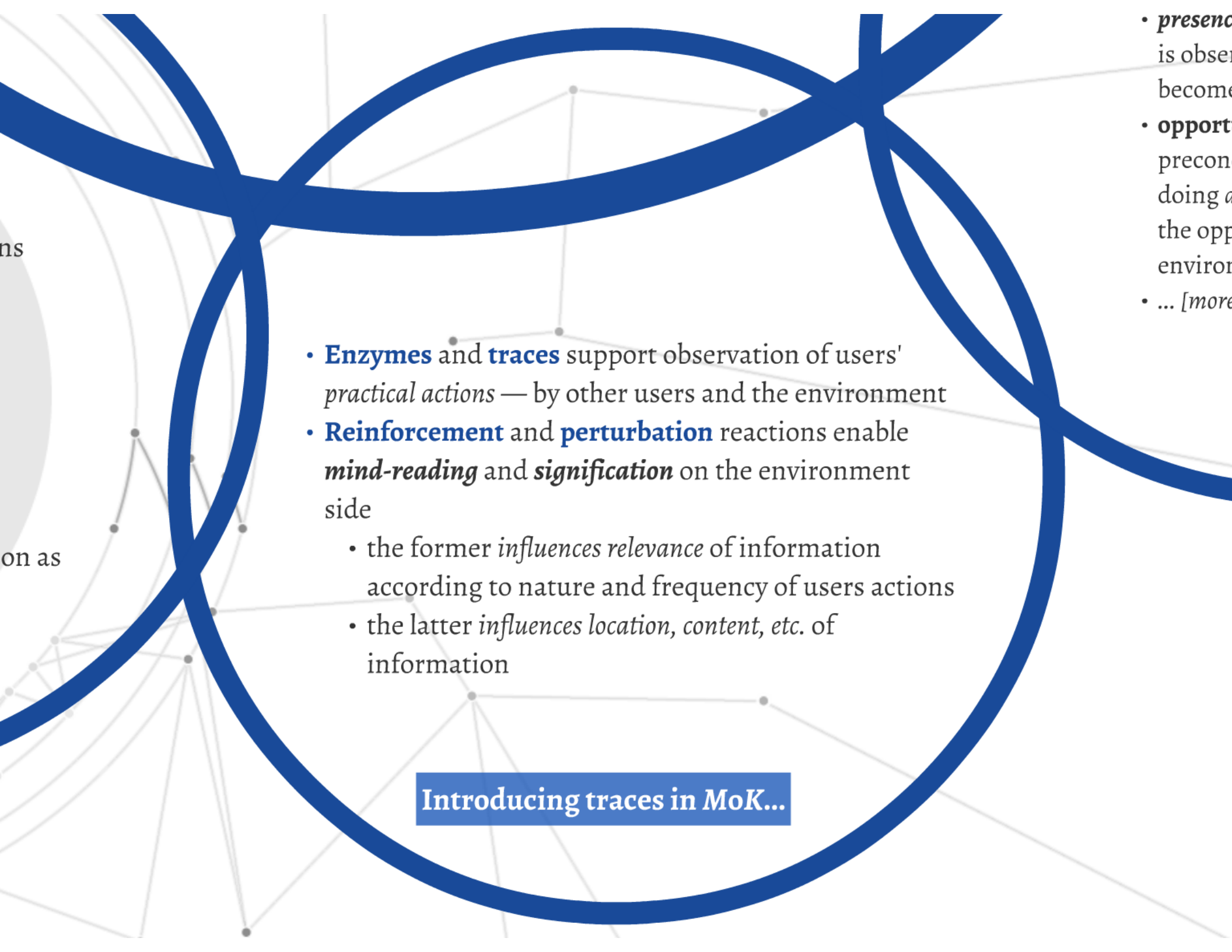
- different forms of **observability** of actions
- **awareness** of this observability

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

- **Enzymes**  
*practical a*
- **Reinforce**  
*mind-read*  
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  - accor
  - the lat
  - inform



- 
- **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...**

- **presence** is observed and becomes
- **opportunities** preconceived doing a the opportunity environment
- ... [more]

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- **opportunities** — “[ $e_1, \dots, e_n$ ] is the set of preconditions for doing  $a$ ”. Agents observing A doing  $a$  may infer that [ $e_1, \dots, e_n$ ] hold, thus, take the opportunity to do  $a$  themselves — the environment too
- ... [more in the paper] ...

...to convey BIC tacit

observation of users'  
s and the environment  
on reactions enable  
on the environment

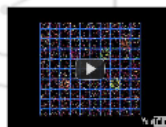
Tacit messages may be recognised in many *heterogeneous knowledge intensive STS* — e.g. Facebook, Twitter, Mendeley, etc.:

- **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 perturbati

# 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*

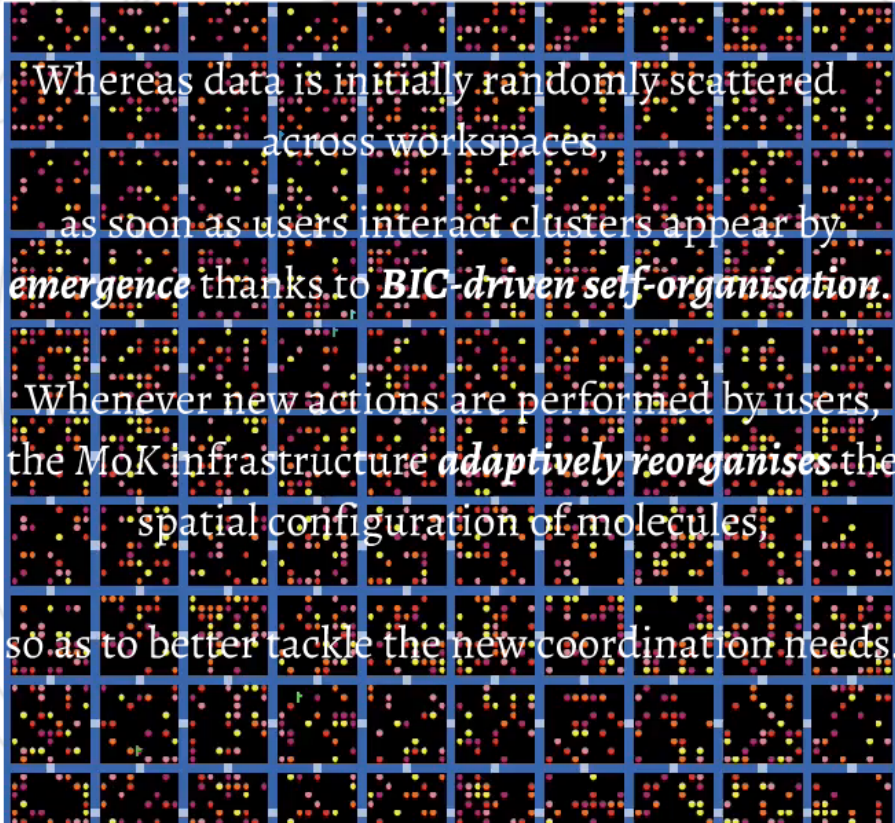
## *Early Results*

- **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

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