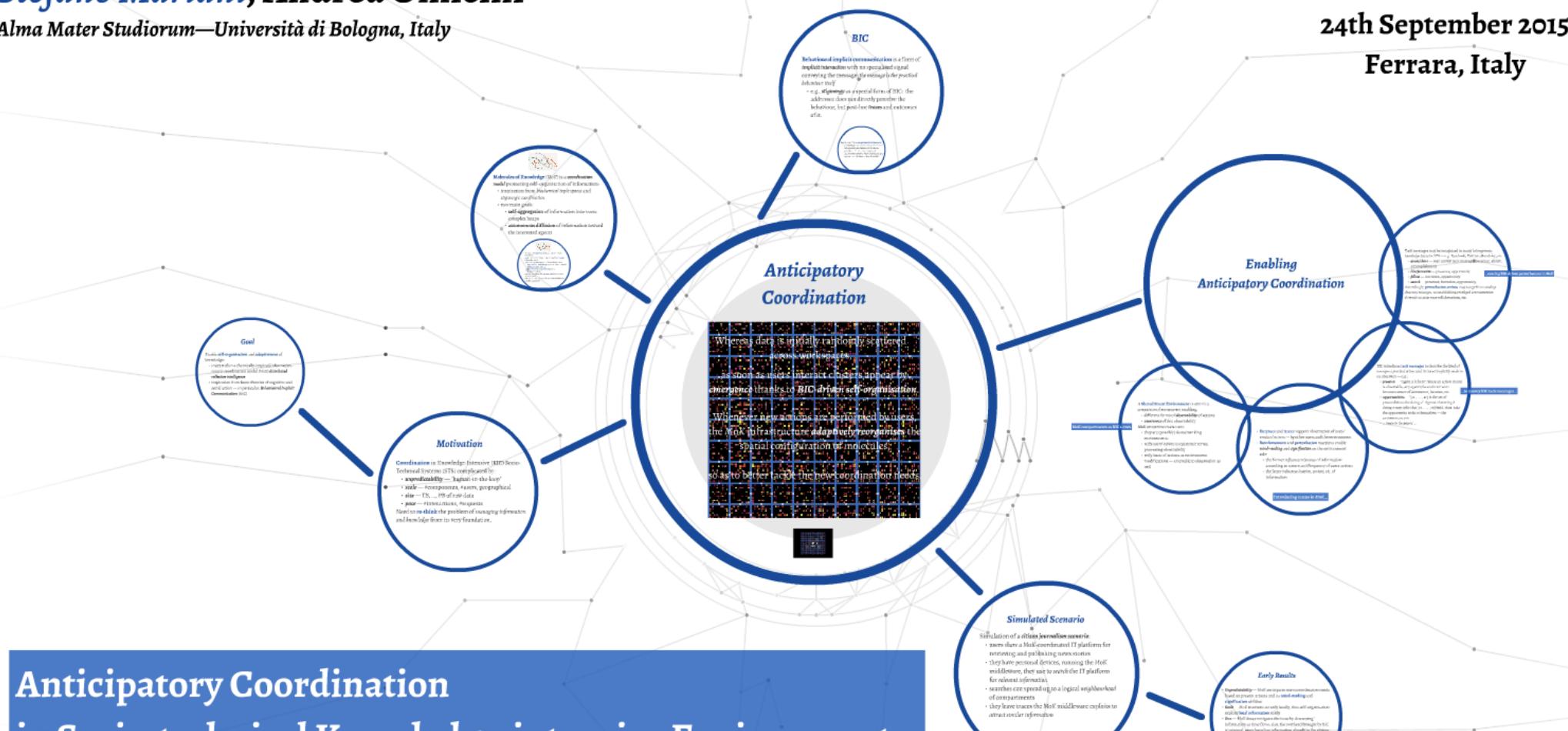


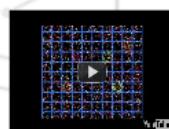
Anticipatory Coordination in Socio-technical Knowledge-intensive Environments: Behavioural Implicit Communication in MoK



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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

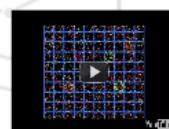


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BIC

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

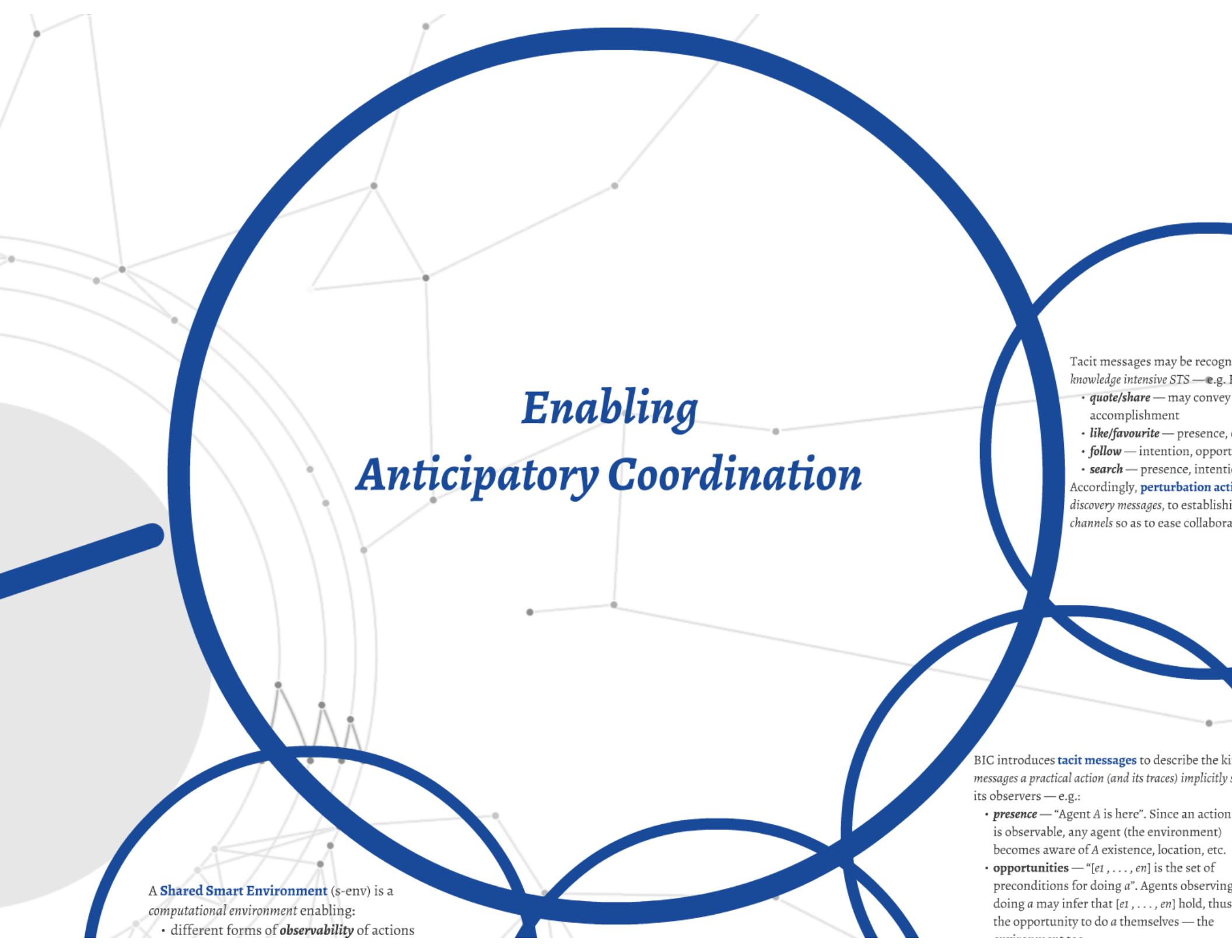
- e.g., *stigmergy* as a special form of BIC: the addressee does not directly perceive the behaviour, but post-hoc *traces* and outcomes of it.

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

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 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 a doing a may infer that $[e_1, \dots, e_n]$ hold, thus the opportunity to do a themselves — the

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

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

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

rtments as BIC s-envs

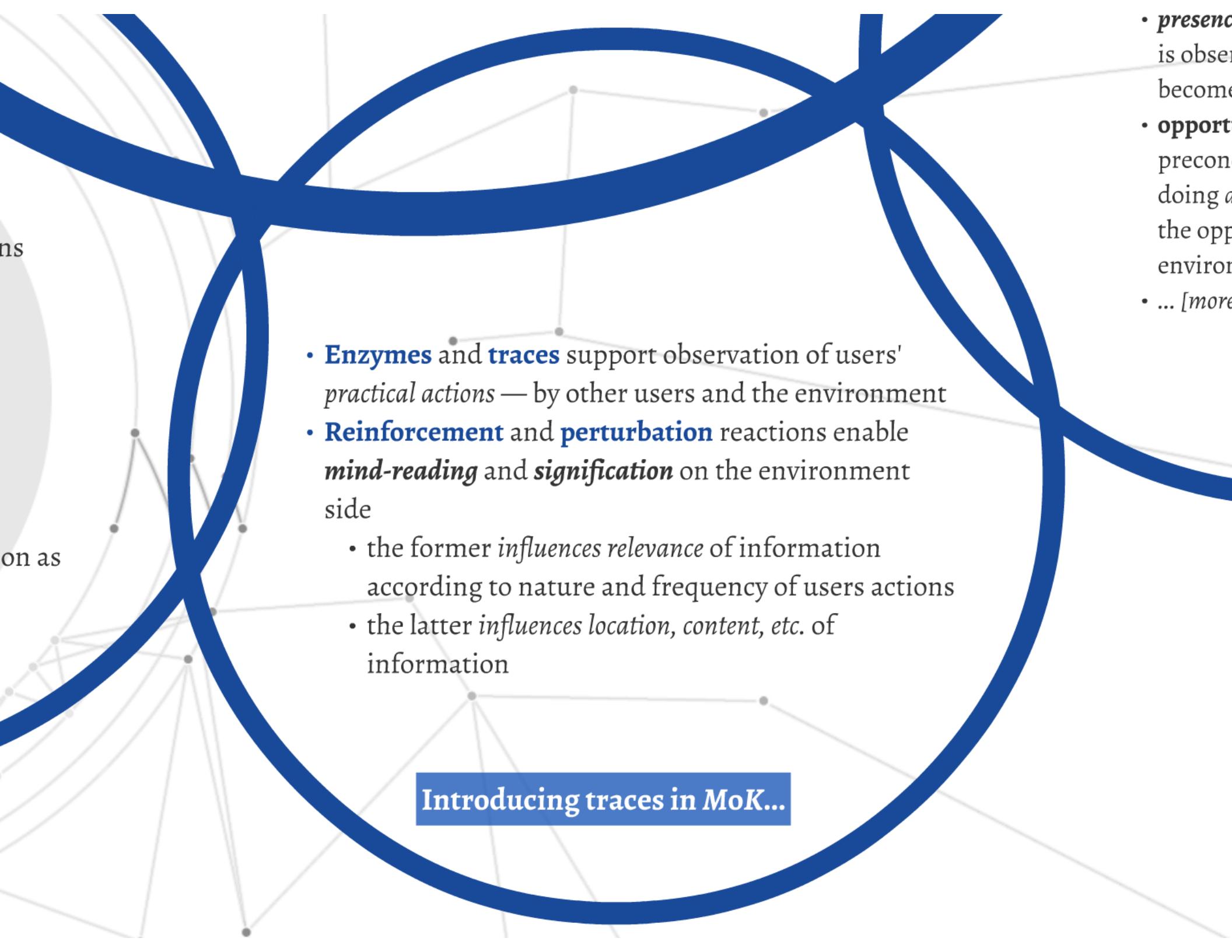
A **Shared Smart Environment** (s-env) is a *computational environment* enabling:

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

MoK compartments are s-env:

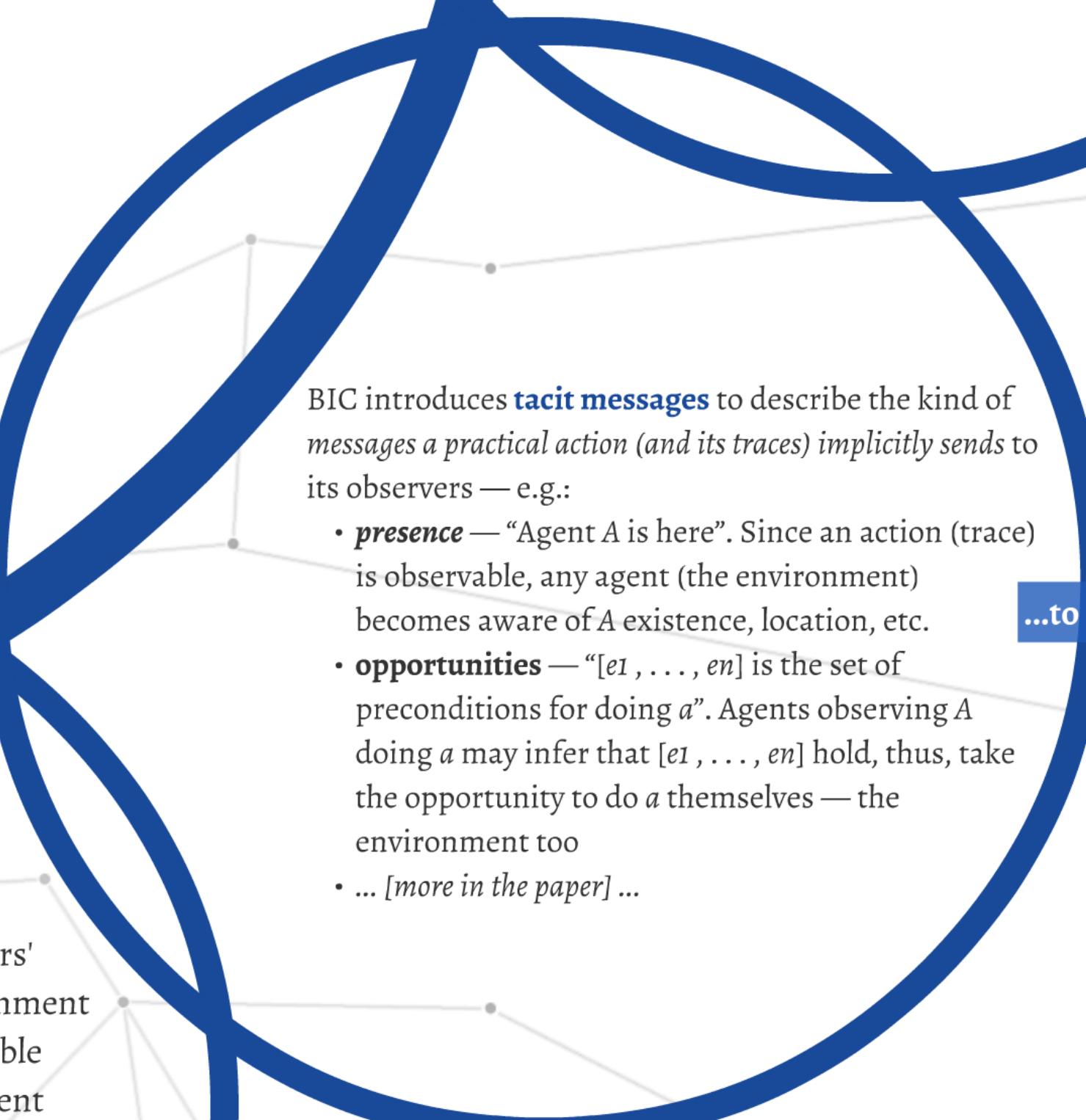
- they are (possibly) *shared* working environments
- reify users' *actions* in epistemic terms, promoting observability
- reify *traces* of actions as environment modifications — amenable to observation as well

- **Enzymes**
practical applications
- **Reinforcement learning**
mind-readiness
- the formalization of
according to the
the latter as
information

- 
- **presence** is observed becoming
 - **opportunities** preconceived doing at the opportunity environment
 - ... [more]

- **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...

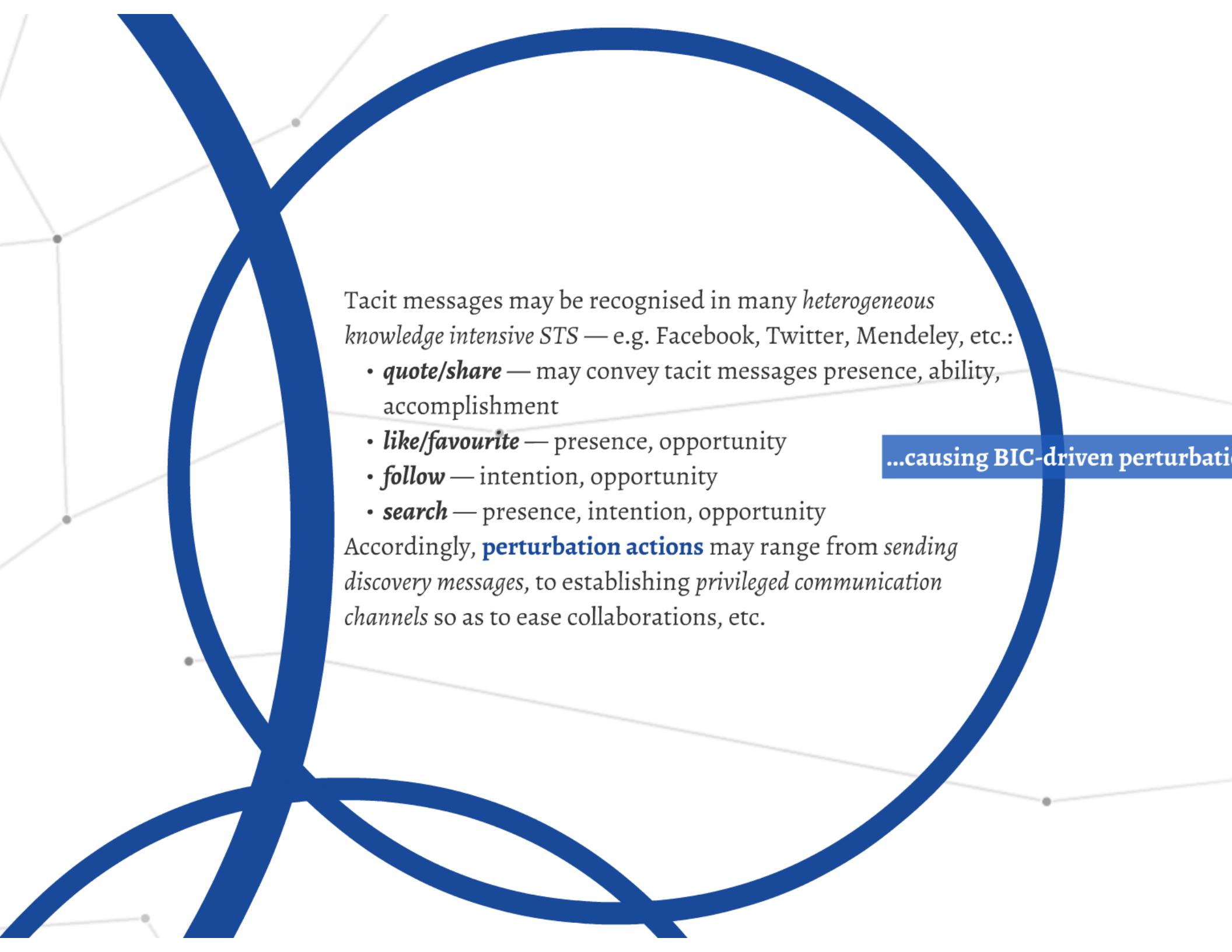


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- **presence** — “Agent A is here”. Since an action (trace) is observable, any agent (the environment) becomes aware of A existence, location, etc.
- **opportunities** — “[e_1, \dots, e_n] is the set of preconditions for doing a ”. Agents observing 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

servation 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

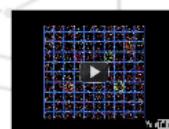
...causing BIC-driven perturbation

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

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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

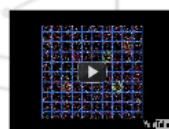
^{*} information is never permanently destroyed, see paper refs.

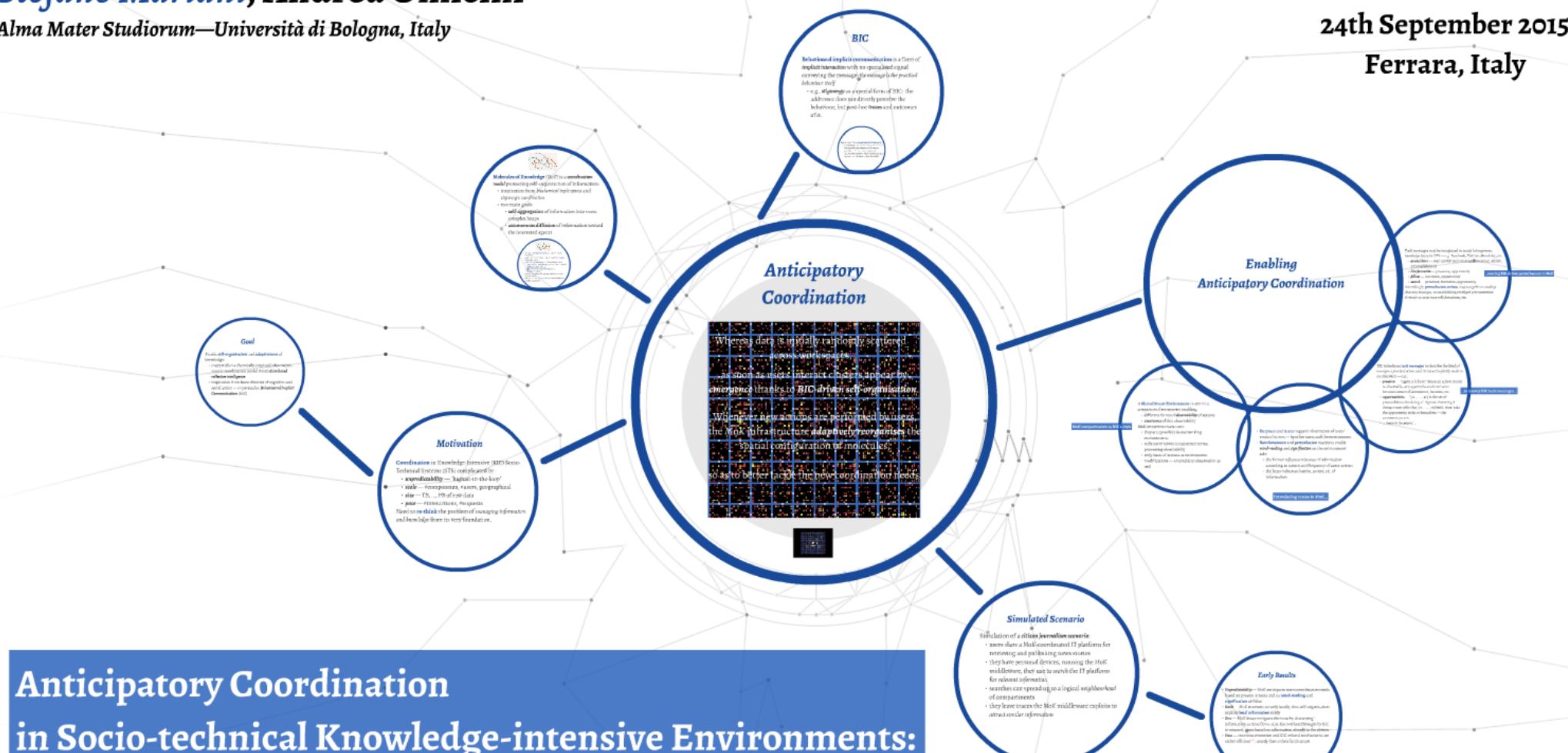
^{**} efficiency strongly depends on the underlying infrastructure

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