Lesson 5 Hypernetworks in Global Systems Science

An Introduction to Hypernetworks

4th Ph.D. summer School - conference on “Mathematical Modeling of Complex Systems”, Cultural Foundation “Kritiki Estia”, Athens

A short course on hypernetworks in the science of complex systems

(You do not need to attend the Athens School to participate in the course.)

How will I study ? For the design of the course and the study pattern click here.

Can I get a certificate ? Yes. The course is assessed by moderated peer marking and is certficated. Click here

Who can participate ? Anyone can join this course. It involves about twenty hours of study.

How do I register ? You can register for the course here. You do not need to attend the Athens School to participate.

What is the schedule ? The schedule is given below.

09-6-2014	**Lesson 0**	**Introduction**	**Lesson 0** text is here	
23-6-2014	**Lesson 1**	**Sets, relations, and the Galois hypergraphs**	**Lesson 1** text is here	**Homework 1** is here
30-6-2014	**Lesson 2**	**Simplicial Complexes and Q-analysis**	**Lesson 2** text is here	**Homework 2** is here
07-7-2014	**Lesson 3**	**Hypernetworks**	**Lesson 3** text is here	**Homework 3** is here
15-7-2014	**Lesson 4**	**Multilevel backcloth and traffic dynamics**	**Lesson 4** slides are here	**Homework 4** will be here
23-7-2014	**Lesson 5**	**Hypernetworks in Global Systems Science**	**Lesson 5** text will be here	**Homework 5** will be here

The Étoile Peer Marking System can be accessed here

This course is sponsored by the Étoile, NESS and TOPDRIM Future and Emerging Technologies projects of the European Commission and certificated in association with the Open University.

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Étoile

Not valid without stamp and authentication code

The Open University

This is to certify that .... *participated in the Étoile course*

An introduction to hypernetworks

(http://www.hypernetworks.info/introductiontohypernetworks.html)

and was awarded the following marks

Knowledge and understanding .... *Peer marking* ....

Signed on behalf of the Étoile Project and the Open University

Jeffrey Johnson

Date

Jeffrey Johnson
Professor of Complexity Science and Design
Faculty of Mathematics, Computing & Technology
The Open University, MK7 6AA, UK
www.complexityanddesign.org

For more information on the Étoile Peer Marking Platform used to evaluate this course see https://etoilepm.cs-dc.org/etoile_login.php

End of Lesson 1

Conclusions

Need a way of representing n-ary relations

Hypergraphs a first step, but not rich enough

Simplicial Complexes are better, but still not rich enough

Hypernetworks complete the relational jigsaw

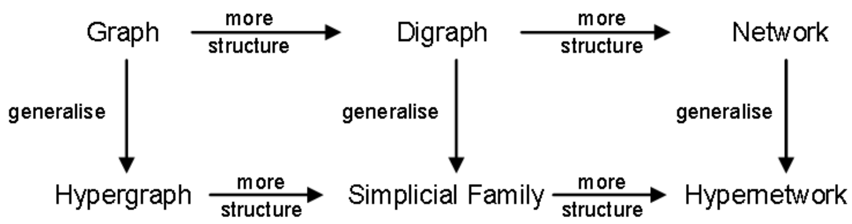


Fig. 4. The relationship between graphs, network, hypergraph and hypernetworks

Hypernetworks can represent multilevel systems

Necessary (if not sufficient) for complex systems

Complex Systems

Generally there is no formula for predicting the future states of complex systems

Sometimes we have ‘transition rules’ from t to t’ > t.

Computing may the only way of knowing possible futures

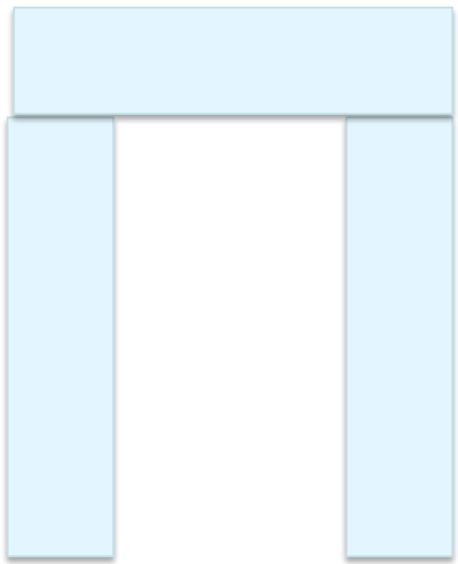
Representation problem:

How can we get this into that?

DIMENSION TESTS

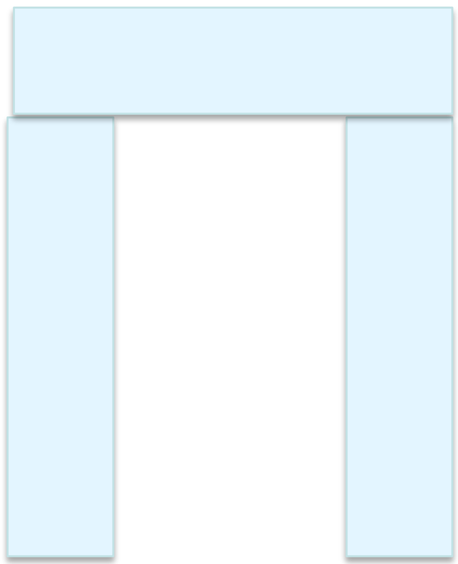
At a given level of representation, a thing has dimension p if it has p+1 parts and they are all necessary for the thing to exist,

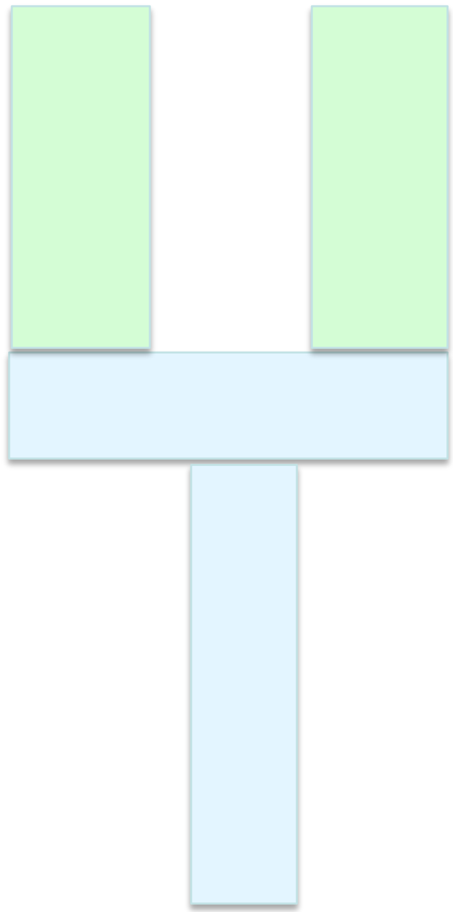
e.g. the arch has dimension p = 2.



DIMENSION TESTS

Some things can be assembled pairwise ($p = 1$) – some cannot ($p > 1$)





What is Global System Science ?

Global = ?

System = ?

Science = ?

What is Global System Science ?

Science = ?

What is Global System Science ?

Science = Telling stories about our world

Using the stories to make predictions

Testing predictions with observation

What is Global System Science ?

Science = Telling stories about our world

Using the stories to make predictions

Sometimes Testing predictions with observation

What is Global System Science ?

Give an example of a scientific prediction that cannot be tested

Science = Telling stories about our world

Using the stories to make predictions

Sometimes Testing predictions with observation

What is Global System Science ?

Give an example of a scientific prediction

that cannot be tested

The climate in 100 years ?

The population of the world in 100 years

Science = Telling stories about our world

Using the stories to make predictions

Sometimes Testing predictions with observation

What is Global System Science ?

System = ?

What is Global System Science ?

System = set of interacting parts or agents

e.g. Greece, car, family, university

What is Global System Science ?

Global = ?

What is Global System Science ?

Global = world wide? Universal ? Whole ?

Examples ?

What is Global System Science ?

Global = world wide? Universal ? Whole ?

- climate change
- the financial system
- cities
- epidemics
- wars
- famine

What is Global System Science ?

Global = world wide? Universal ? Whole ?

many
global
system
are
coupled

climate change
the financial system
cities
epidemics
wars
famine
energy

What is Global System Science ?

Global = whole system, worldwide, universe

System = set of interacting parts or agents

Science = Telling stories about our world
Using them to make predictions
Testing predictions … … … ? ? ?

What is Global System Science ?

Do we have a Global System Science ?

What is Global System Science ?

Do we have a Global System Science ?

Do we need a Global System Science ?

What is Global System Science ?

Do we have a Global System Science ?

NO !

Do we need a Global System Science ?

YES !

What is Global System Science ?

Do we have a Global System Science ?

NO !

Do we need a Global System Science ?

YES !

Where would *YOU* start ?

What is Global System Science ?

Do we have a Global System Science ?

NO !

Do we need a Global System Science ?

YES !

Where would *YOU* start ?

Maybe a theory of *time* and *space* ?

What is Global System Science ?

Do we have a Global System Science ?

NO !

Do we need a Global System Science ?

YES !

Where would *YOU* start ?

Maybe a theory of *time* and *space* ?

Dynamics - System time and System Events

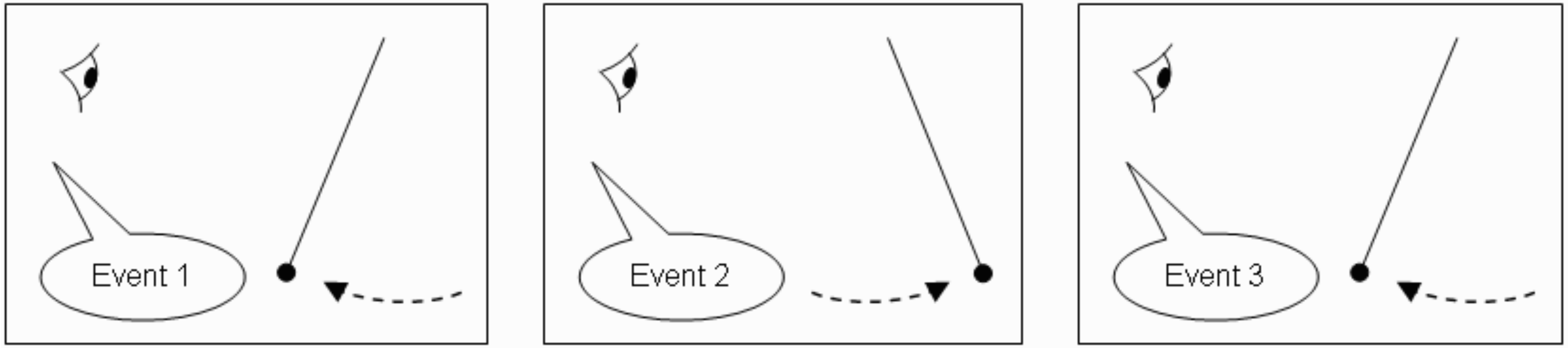


Figure 18: Pendulum events used to measure clock time

System time and System Events

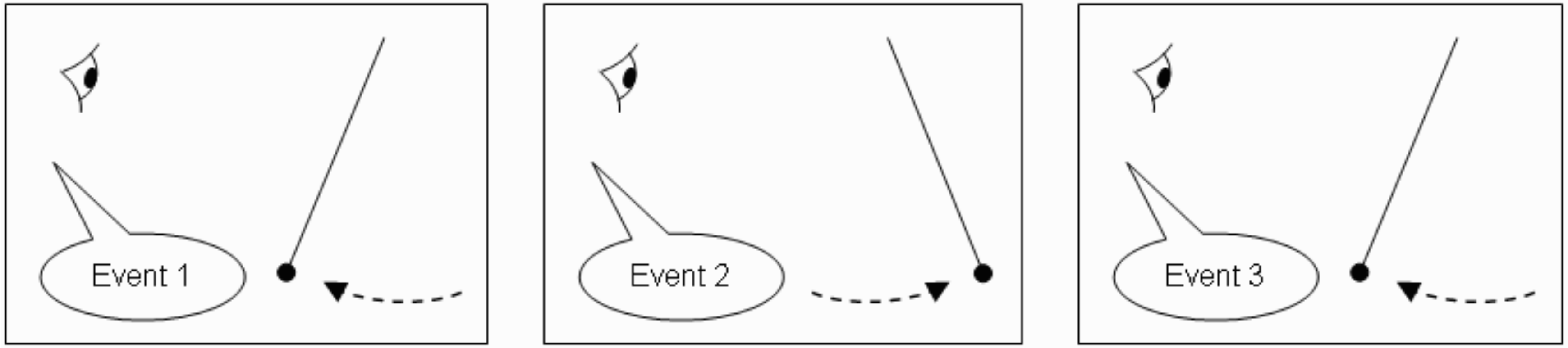
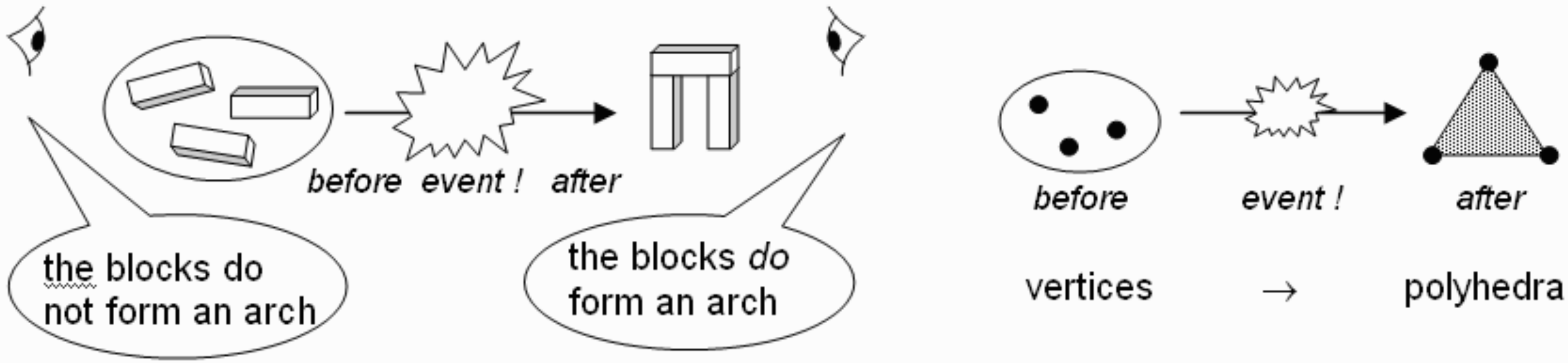


Figure 18: Pendulum events used to measure clock time



(a) assembling elements to form a structural event (b) a polyhedral event

Figure 19. The formation of polyhedral structure marks system events

System time and System Events

Examples of events in social space-time ?

System time and System Events

Examples of events in social space-time ?

first love	Life is never
getting your PhD	the same
learning to drive	after events
having a baby	like these
first time in Greece	

System time and System Events

Events mark social time =/= clock time

Events are hypersimplices !

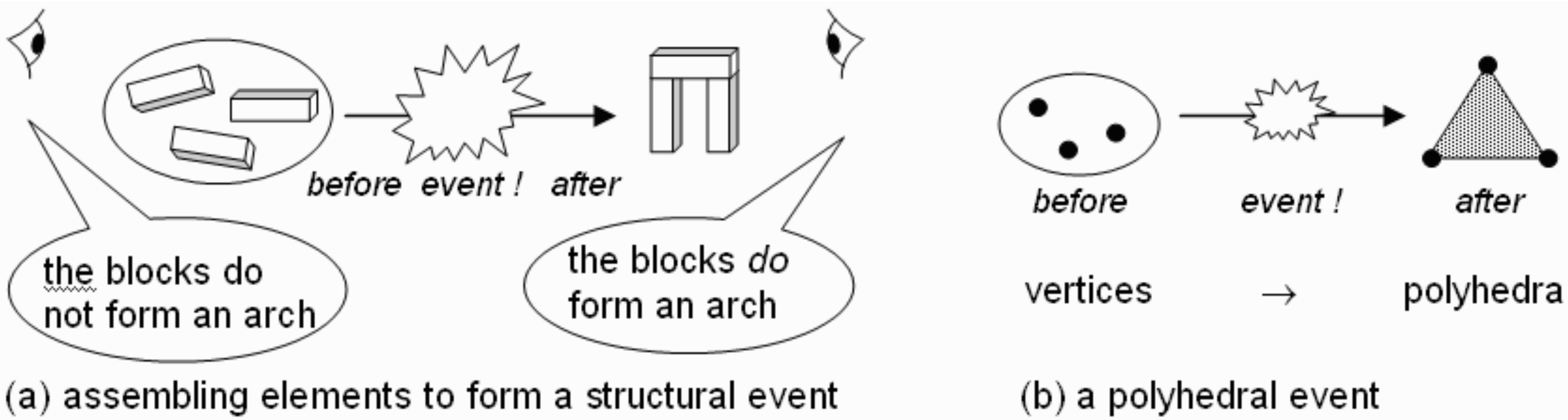


Figure 19. The formation of polyhedral structure marks system events

System time and System Events

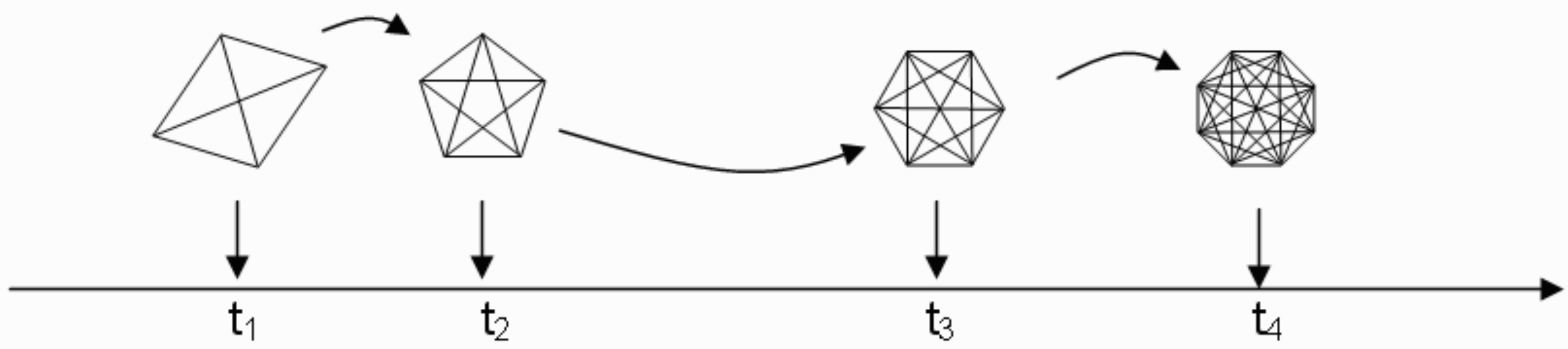


Figure 21. System event dynamics form trajectories in a non-linear way in clock time

Planning involves changing *relations*

System time and System Events

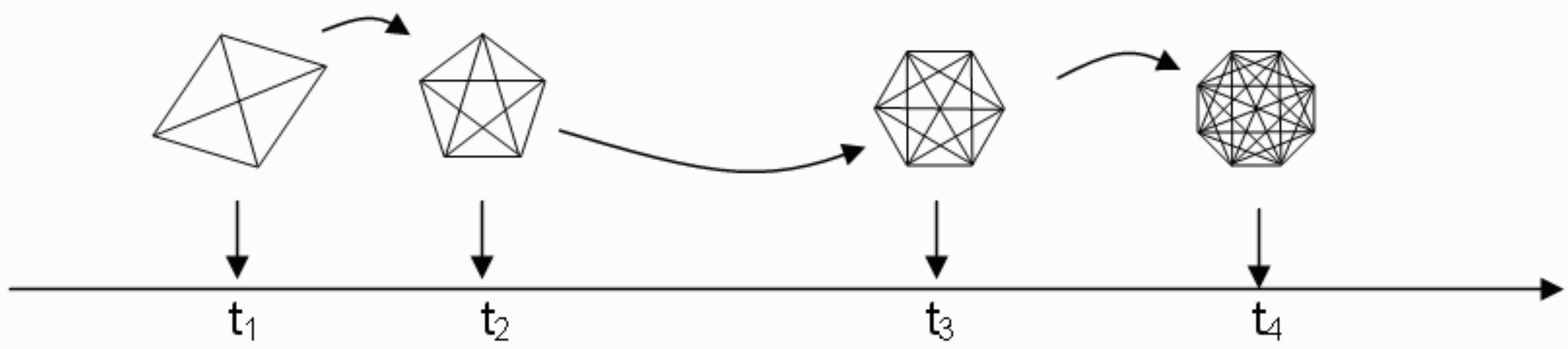


Figure 21. System event dynamics form trajectories in a non-linear way in clock time

System dynamics involves changing *relations*

… trajectories of multidimensional events

System time and System Events

Wednesday

16:00 – 18:00	***Afternoon session***
16:00 – 18:00	“*Hypernetworks in Global Systems Science* “ Jeff Johnson (British Open University)
18:00 – 19:00	Poster Session

Thursday

9:30 – 14:00	***Morning session***
9:30 – 11:30	“*Mathematical Modeling of Complex Systems II*” Tassos Bountis (University of Patras)
11:30 – 12:00	Coffee break
12:00 – 14:00	“*Complex Dynamics and Self-Organization of Granular Matter I*“ Ko van der Weele (University of Patras)

System time and System Events

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Ko van Wheele

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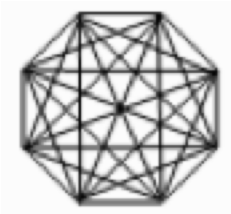
Jeff Johnson

System time and System Events

The plan – maps social time into clock time

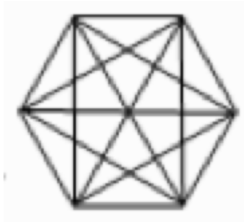
Jeff Johnson social time ➔

Event 1



Submit Etoile Reports

Event 2



Give Lecture 2

Mon	Tues	Wed	Thurs
Brussels Deadline	Brussels Deadline + 1	Brussels Deadline + 2	Today !

Clock time ➔

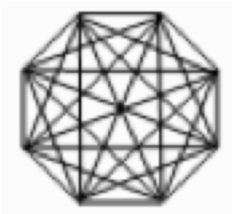
System time and System Events

The plan – maps social time into clock time

Jeff Johnson social time ➔

Reports not ready – event can't happen- move it ! ! ! ! !

Event 1



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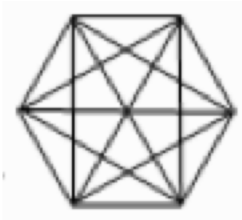

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System time and System Events

The plan – maps social time into clock time

Jeff Johnson social time →

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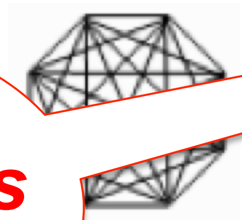

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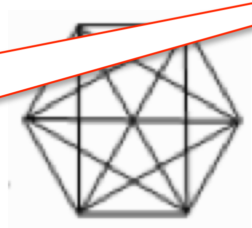


Prof Bountis Help ! ! !

ile Reports

Give Lecture 2

Reports still not ready – event can't happen- Moved event clashes ! ! !

Mon	Tues	Wed	Thurs
Brussels Deadline	**Brussels Deadline + 1**	**Brussels Deadline + 2**	**Today !**

Clock time →

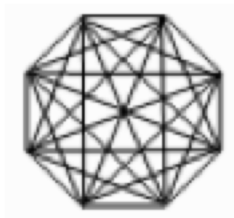
System time and System Events

The plan – maps social time into clock time

Jeff Johnson social time ➔

Reports finished - event can happen

Event 1



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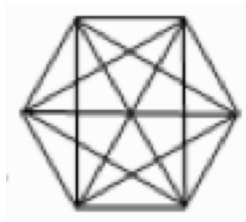
Event 2



Give Lecture 2

Mon
Brussels Deadline

Tues
Brussels Deadline + 1

Wed
Brussels Deadline + 2

Thurs
Today !

Clock time ➔

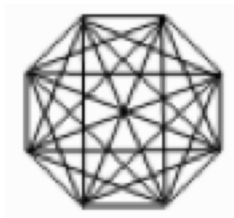
System time and System Events

The plan – maps social time into clock time

Jeff Johnson social time ➔

event has happened

Event 1



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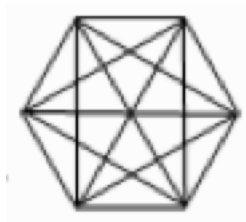
Event 2



Give Lecture 2

Mon	Tues	Wed	Thurs
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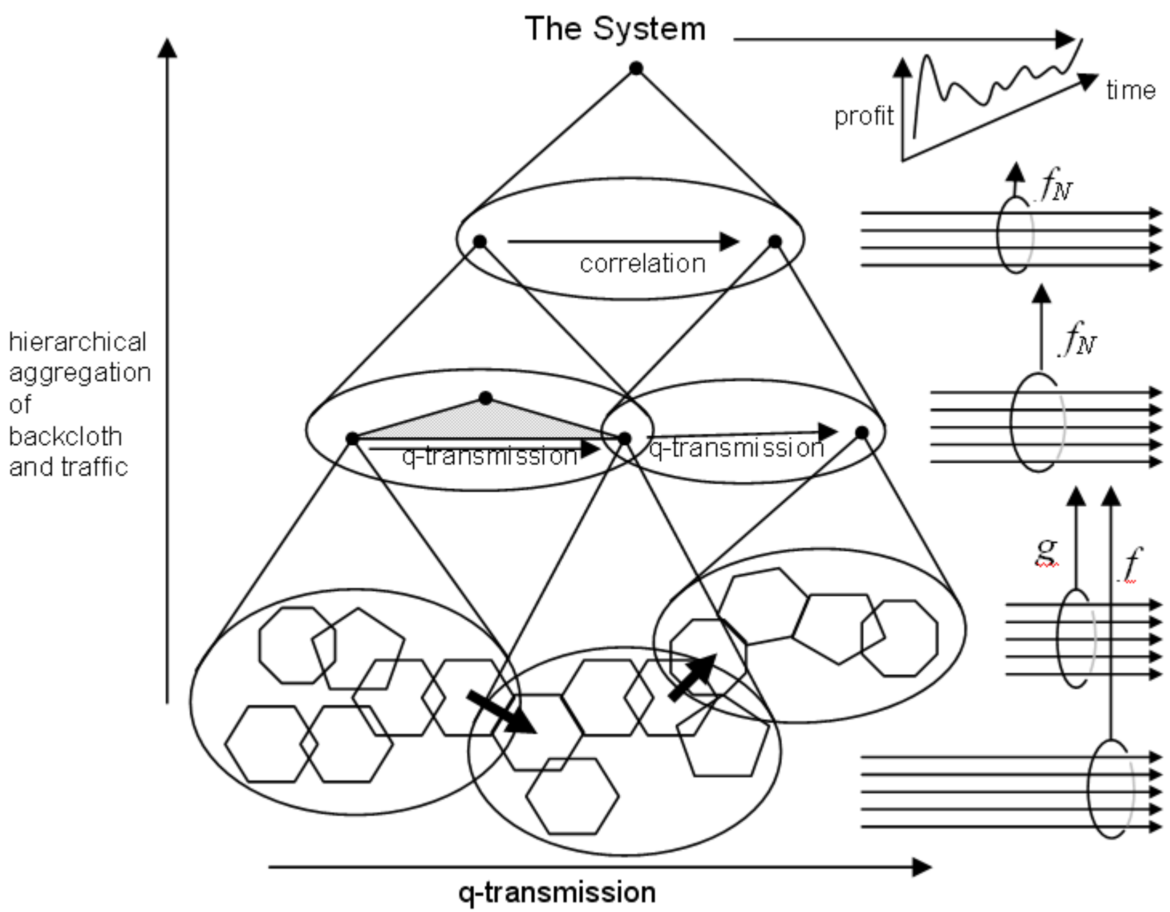
Clock time ➔

Representing Global Systems & Dynamics

Backcloth, Traffic & Type-1 Dynamics



Cannot look at just one level

Traffic must aggregate coherently over the structure

Traffic on the multi-level backcloth - coherence

Global Systems Science & Policy

Global System Science

Policy – Designing the Future

Complex Systems, Design and Policy

Global Systems Science

Global – can mean 'worldwide'

but also 'the <u>whole</u> system'

Examples: cities
financial systems
climate change

systems of
systems of
systems …

Global Systems Science

Global – can mean 'worldwide'

but also 'the whole system'

Examples: cities
financial systems
climate change

systems of
systems of
systems …

Question – what are the subsystems ?

Global Systems Science

Global – can mean 'worldwide'

but also 'the whole system'

Examples: cities
financial systems
climate change

systems of
systems of
systems …

Question – what are the subsystems ?

Are they necessary to 'predict' dynamics of the whole?

Global Systems Science

Policy informatics

The use of computer ICT systems to support policy

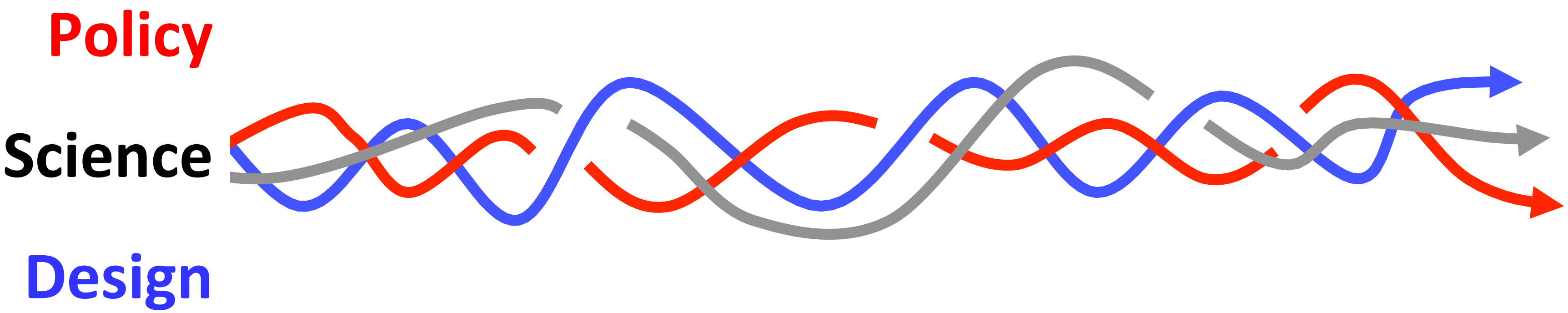
knowledge and theory is *inside* computers

knowledge and theory are *explicit*

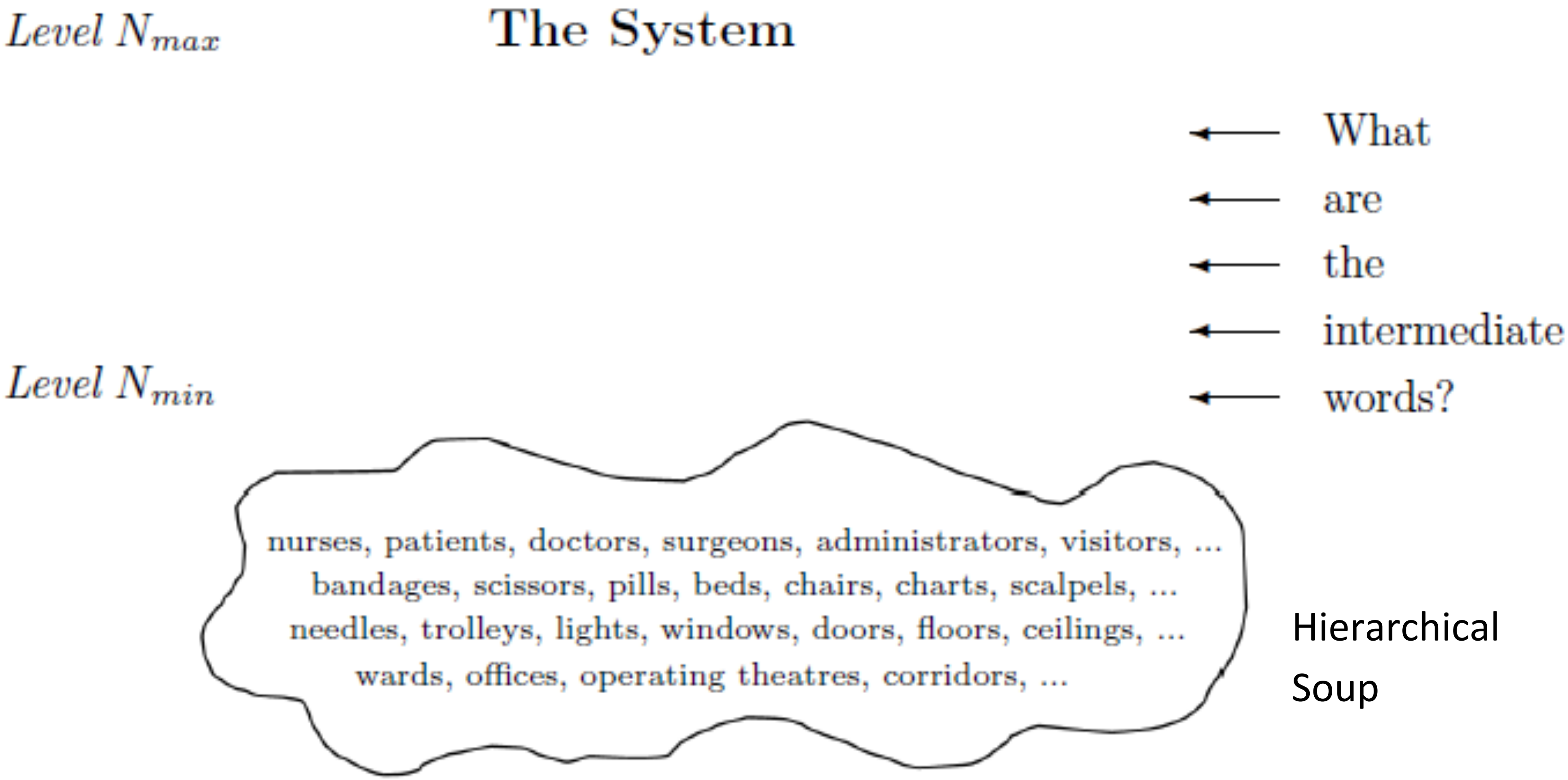
Policy

Policy is ***designing*** the future

Policy as designing the future is *entangled* with complexity science and design



Policy is designing the future



Design is an Intermediate Word Problem

What are the intermediate structures ?

What shall we call them ?

Policy is designing the future

Innovation involves creating artificial systems

Creating artificial systems involves **Design**

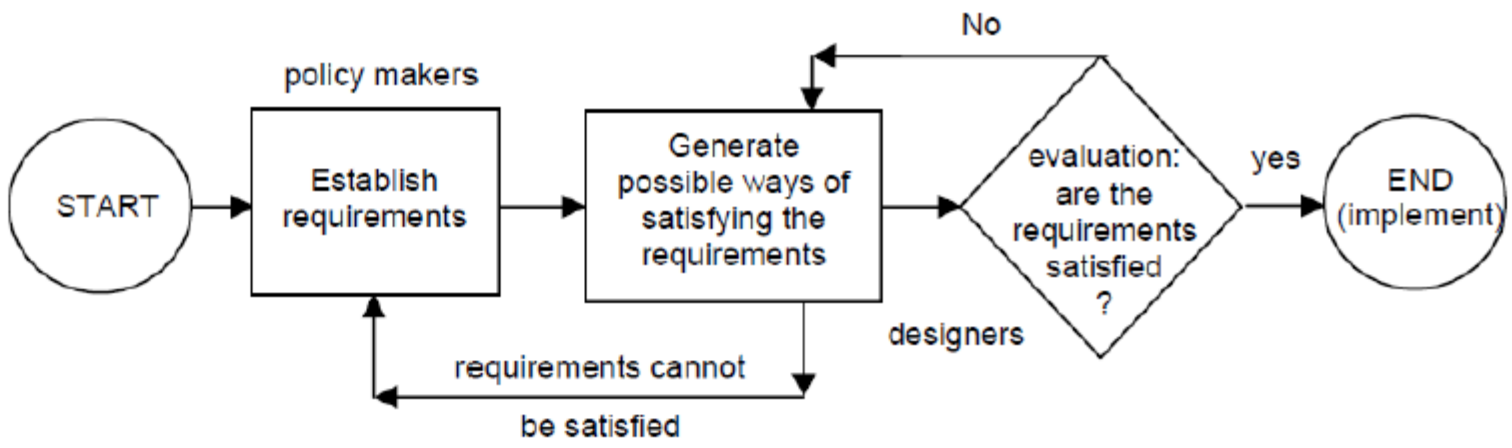


Fig. 1 The simplified requirements-generate-evaluate model of the design process

Design a co-evolution between what you think you want & what you think you can have

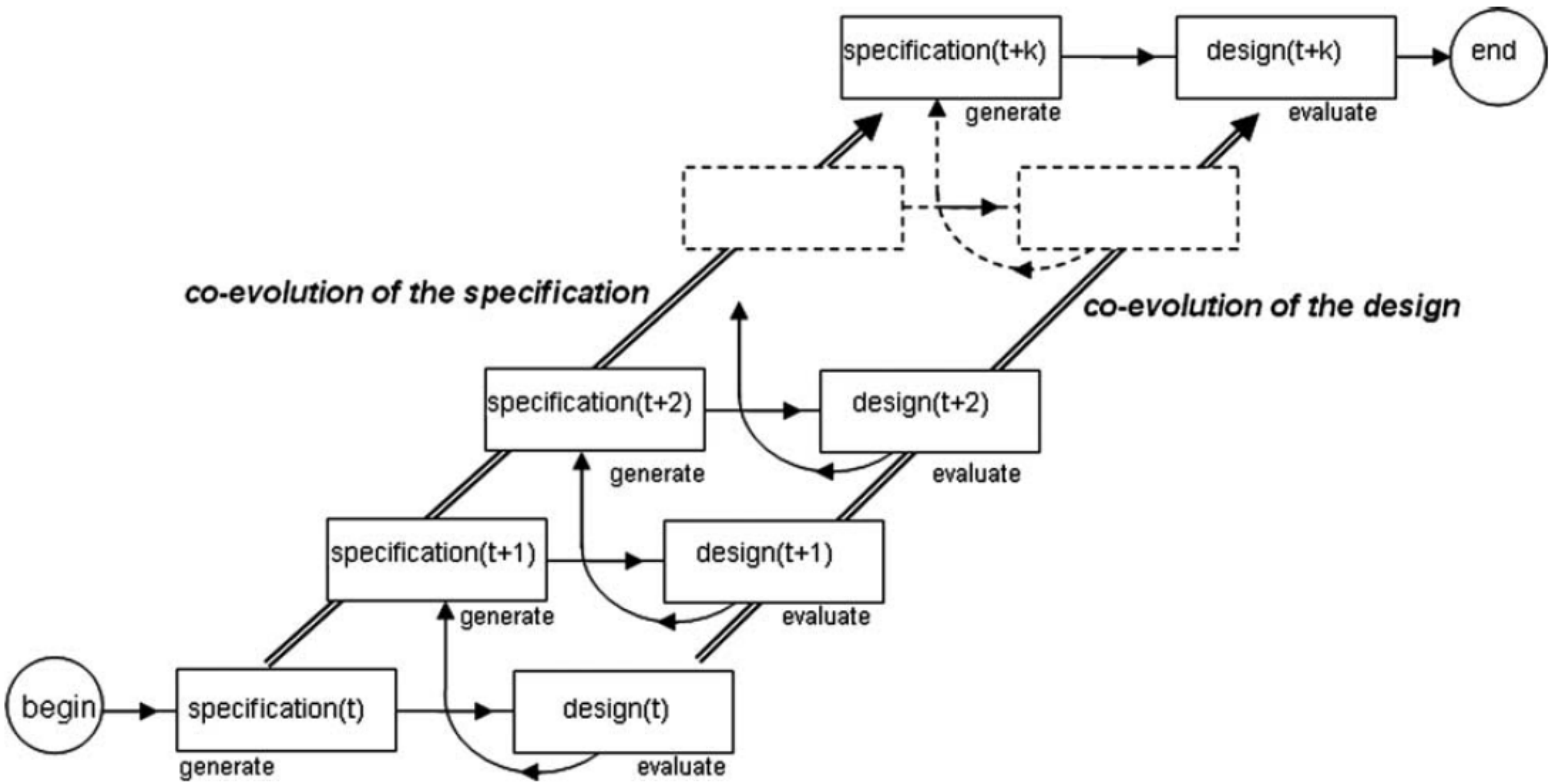


Fig 2. The co-evolution between specification and design through a generate–evaluate spiral.

Design is an iterative *process* – it takes time

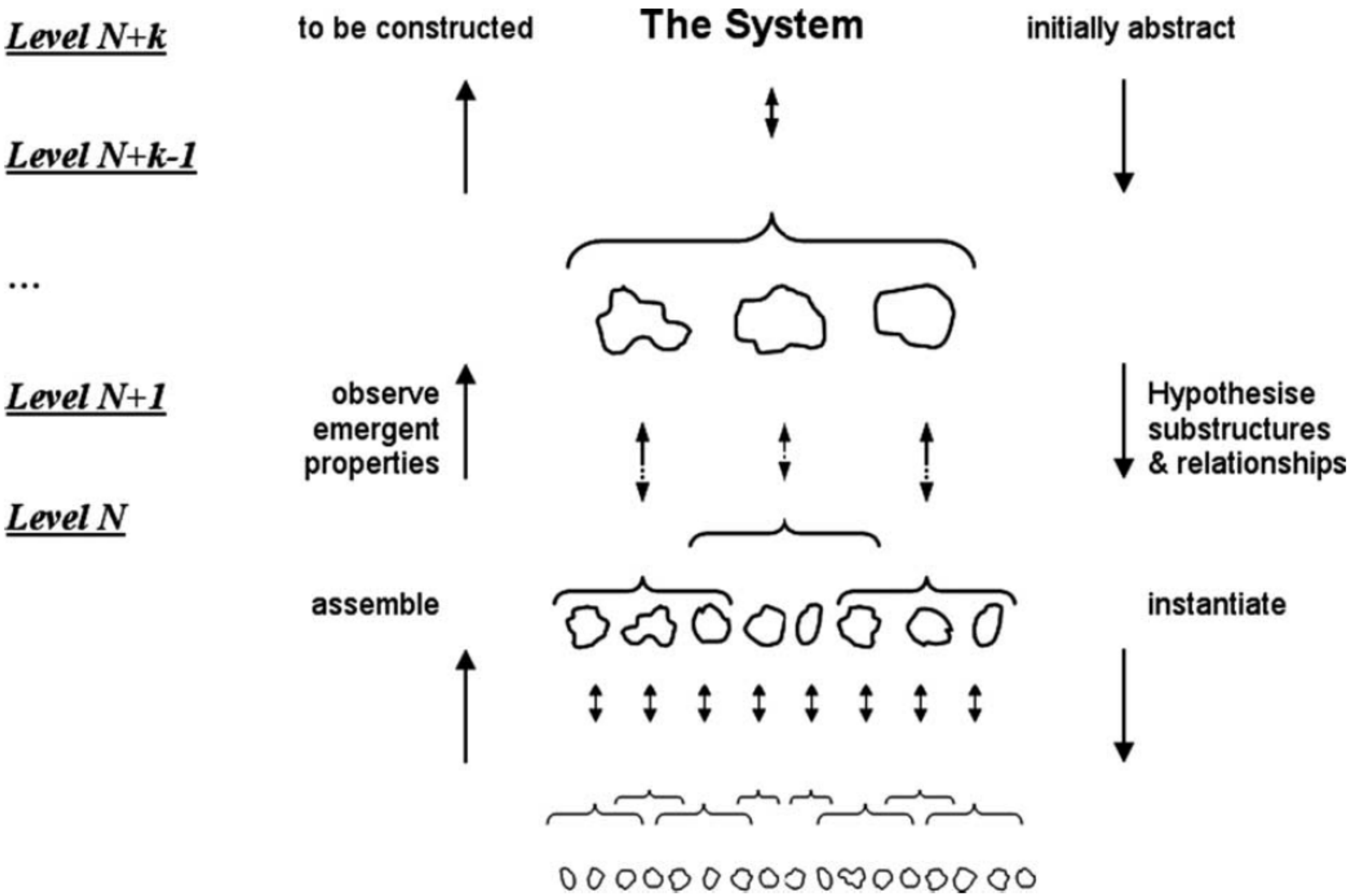


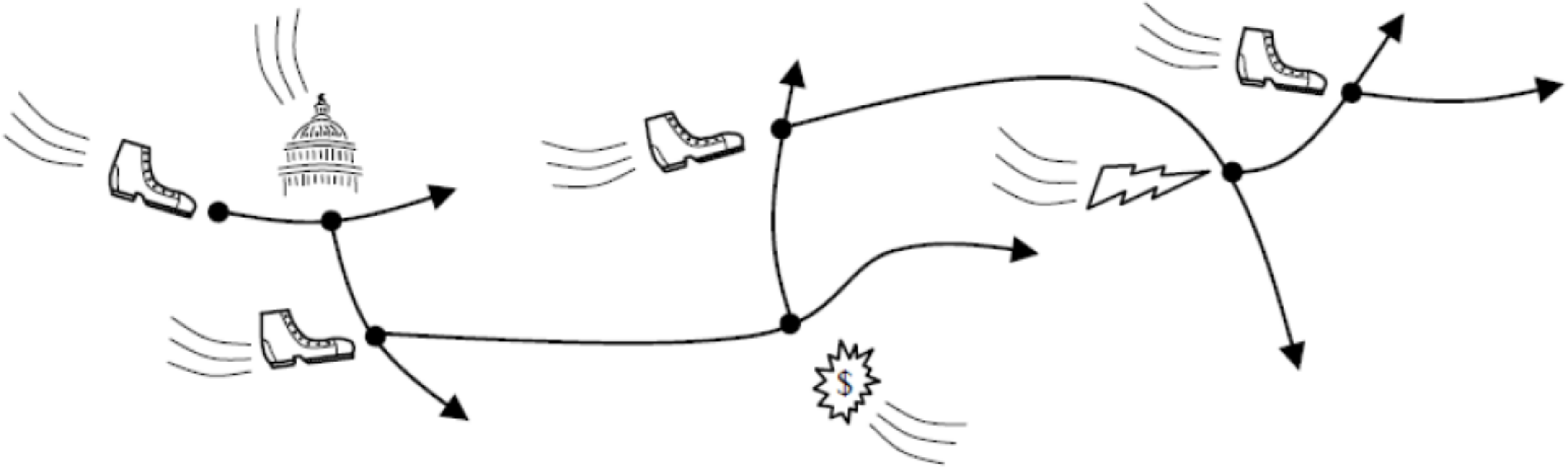
Fig 3. Design as bottom-up construction and top-down hypothesis, generation and reasoning.

Almost all policy interventions are experiments

Experiment as predicting that an intervention kicks will result in a future target state

Almost all policy interventions are experiments

Experiment as predicting that an intervention kicks will result in a future target state



What does 'prediction' mean when the system is continually knocked of trajectory

4. Example

Policy for street gangs following the 2011 London riots

theguardian

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News › UK news › London

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London riots aftermath - Monday 8 August 2011

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Police confront youths in Hackney, London. Photograph: BBC

Posted by
Matt Wells and Sam Jones
Friday 13 July 2012 04.54 EDT
guardian.co.uk
Jump to comments (1733)

Article history

UK news
London · Metropolitan police · Police · Hackney · Tottenham · UK riots 2011

Series
UK riots live

More from News blog on

7.37am: Good morning, and welcome to the Guardian's live reaction to London disturbances. A second night of rioting broke out across London last night, with violence erupting in several of the capital's boroughs, from Brixton in the south to Enfield and Islington in the north and

Street gangs played a big part in the riots

'Ending Gang & Youth Violence', published in Nov 2011 Secretary of State for the Home Department was the basis for a policy response to the riots.

"One thing that the riots in August did do was to bring home to the entire country just how serious a problem gang and youth violence has now become."

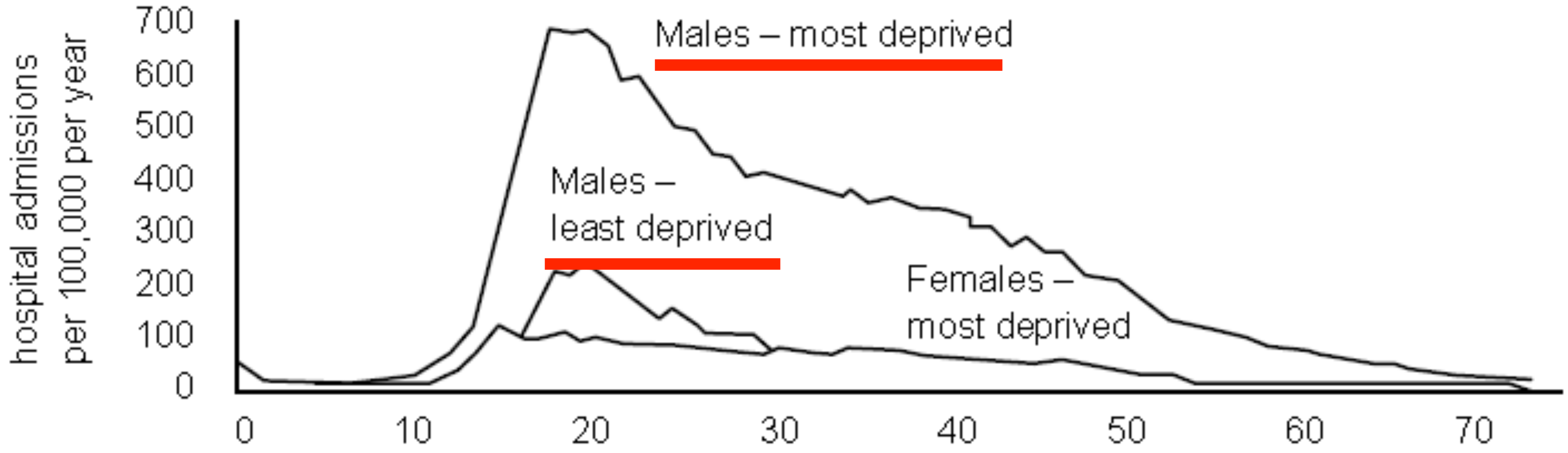


Fig. 7. Admissions to English NHS hospitals for assault involving 13 to 14 year olds. [11]

High levels of violence are partly associated with street gangs

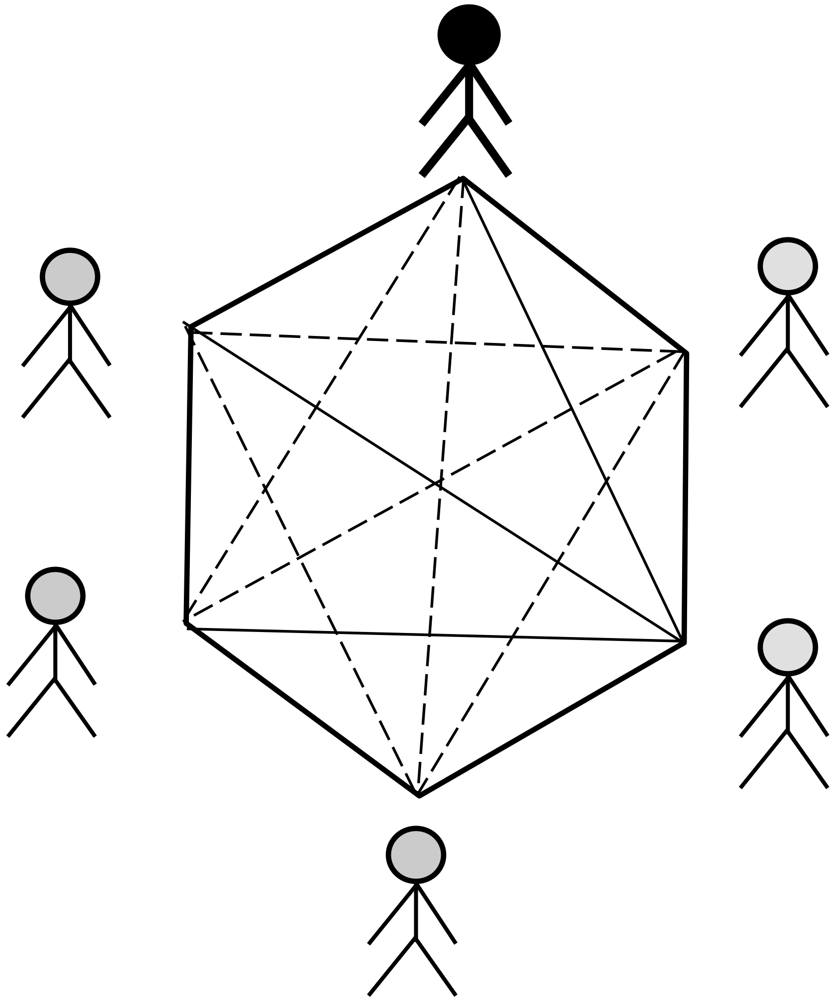
2012 Centre for Social Justice report ‘Time to Wake Up’ :

Was police practice of identifying and removing gang ‘elders’ effective?

“it seems that an unintended consequence of the arrest of senior gang members has been to heighten tensions and violence. …

There was a consensus that the current gangs neither have no cohesive leadership, which is resulting in increased chaos, violence and anarchy. [14]

“it seems that an unintended consequence of the arrest of senior gang members has been to heighten tensions and violence. …



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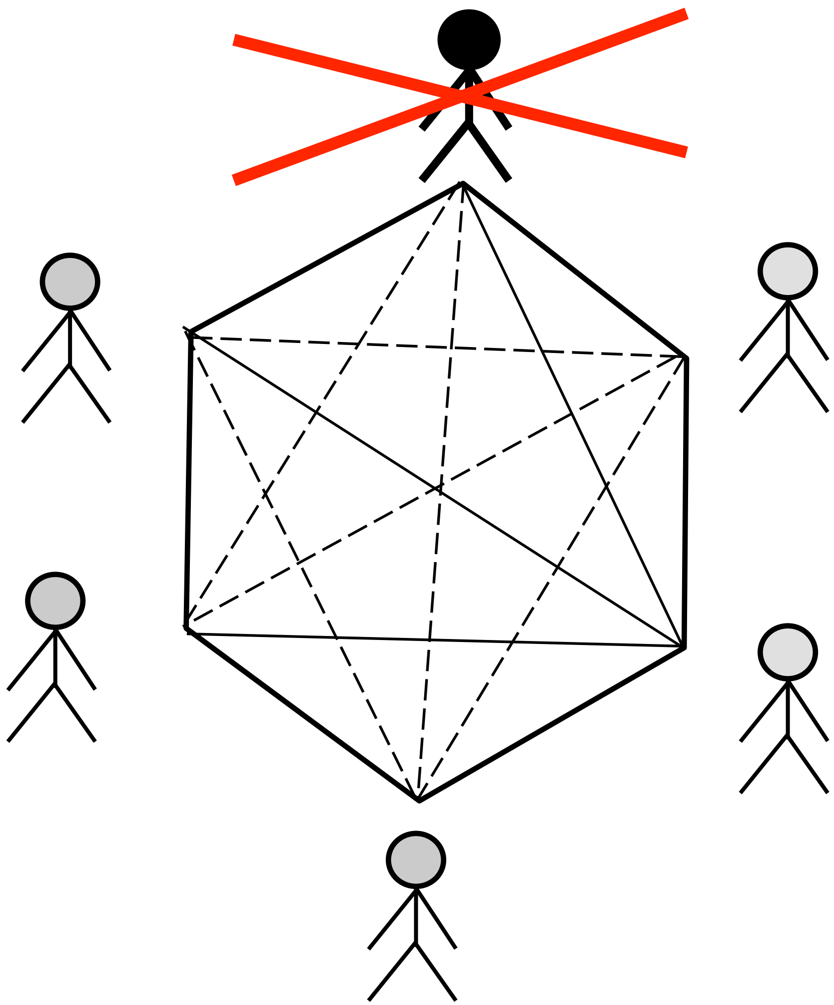

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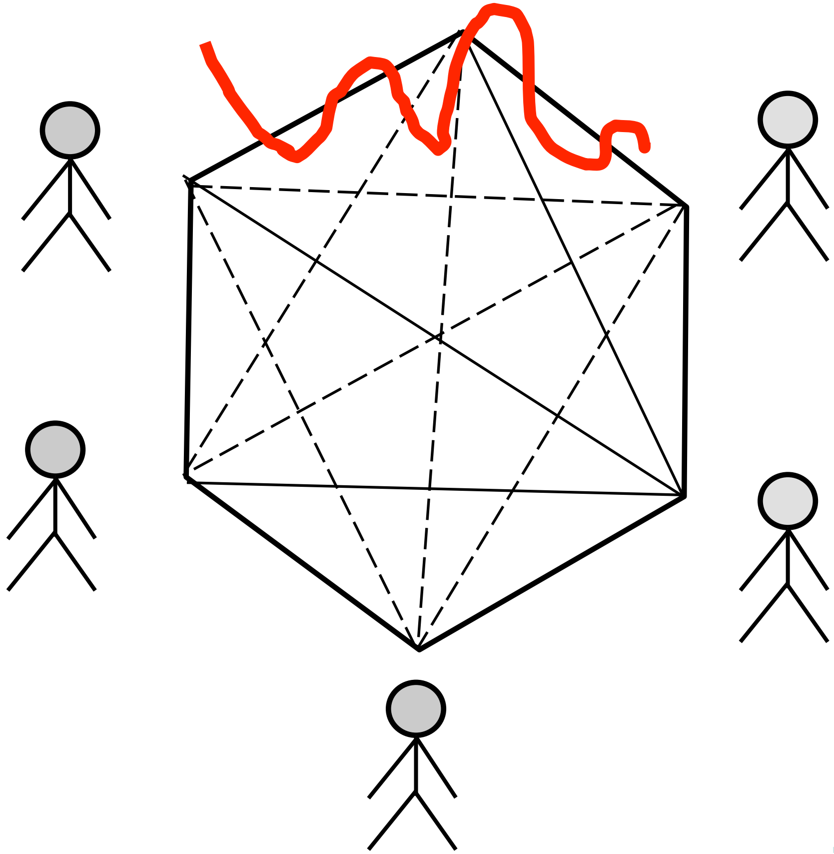


Policy –

How to predict the outcome of interventions?

What are the dynamics of the hypersimplices?

no cohesive leadership → increased chaos, violence anarchy.

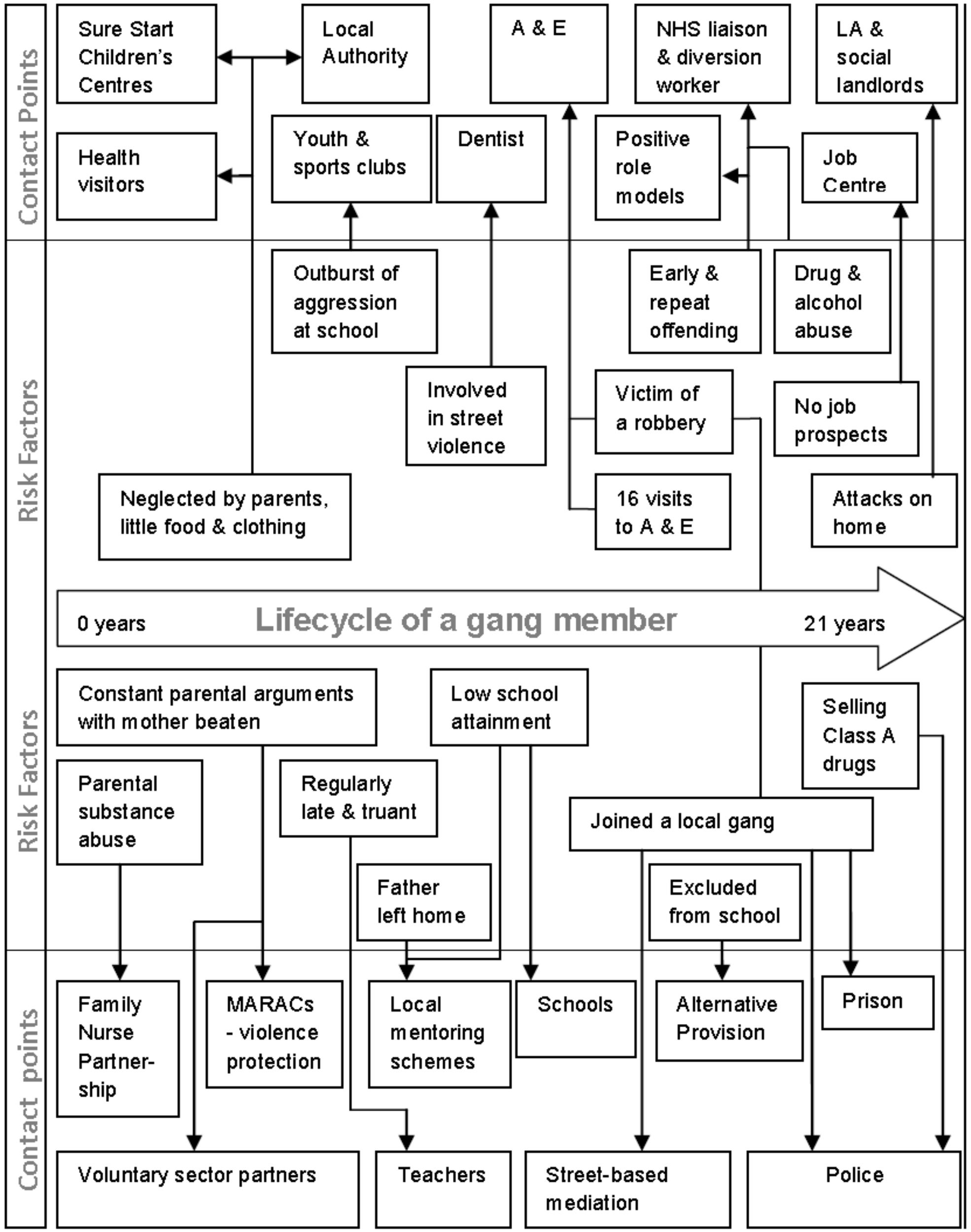


Fig. 8. The lifecycle of a gang member (Source: HMG: Ending Gang Youth Violence [13]).

The lifecycle of a gang member

Hypersimplices:

$\langle$neglected by parents, parental substance abuse, parental violence; $R_{experienced\_0\text{-}5}\rangle$

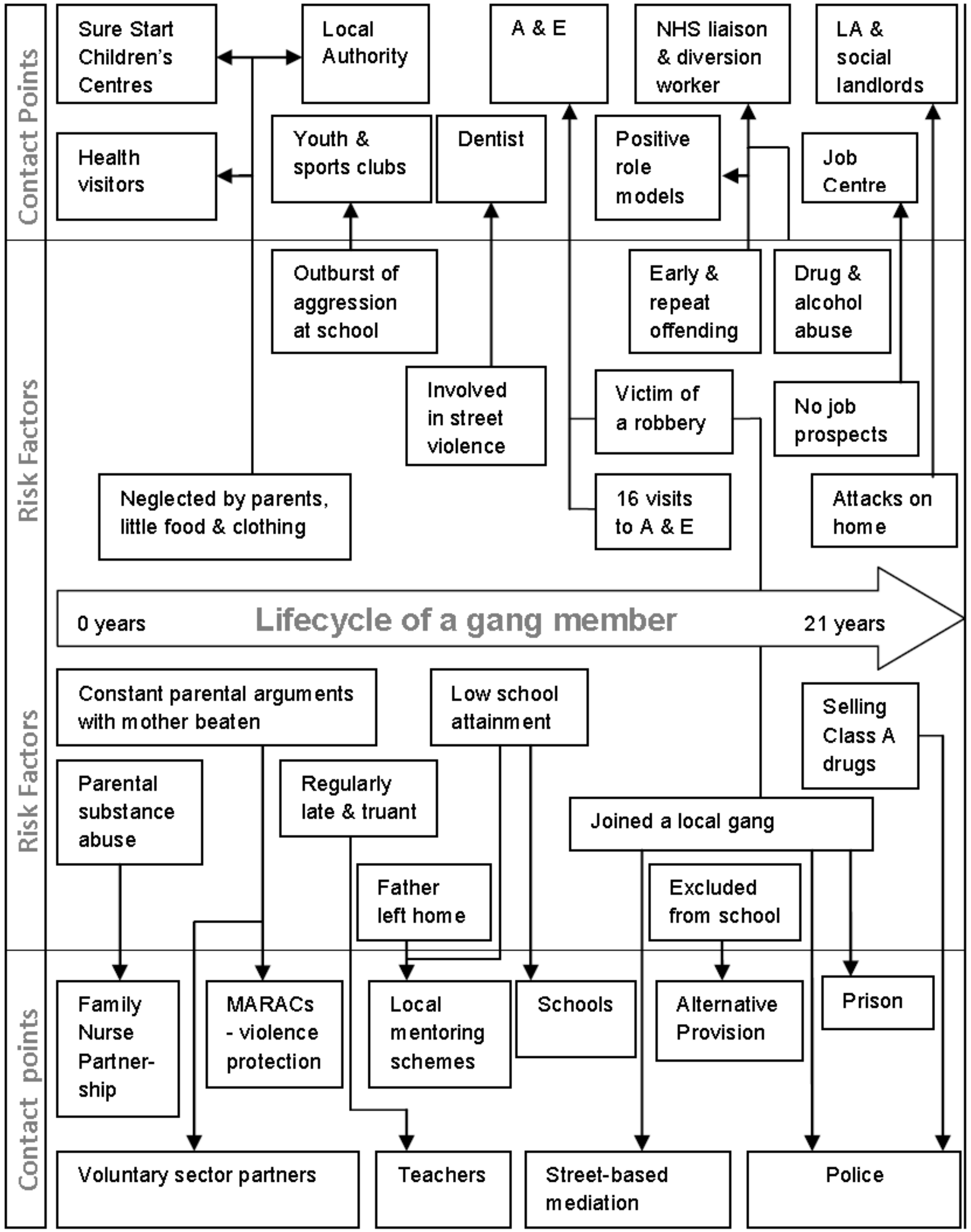


Fig. 8. The lifecycle of a gang member (Source: HMG: Ending Gang Youth Violence [13]).

The lifecycle of a gang member

Hypersimplices:

⟨outbursts of aggression as school,
involved in street violence,
many visits to A&E;
$R_{\_10\text{-}15}$ ⟩

Child getting violent !

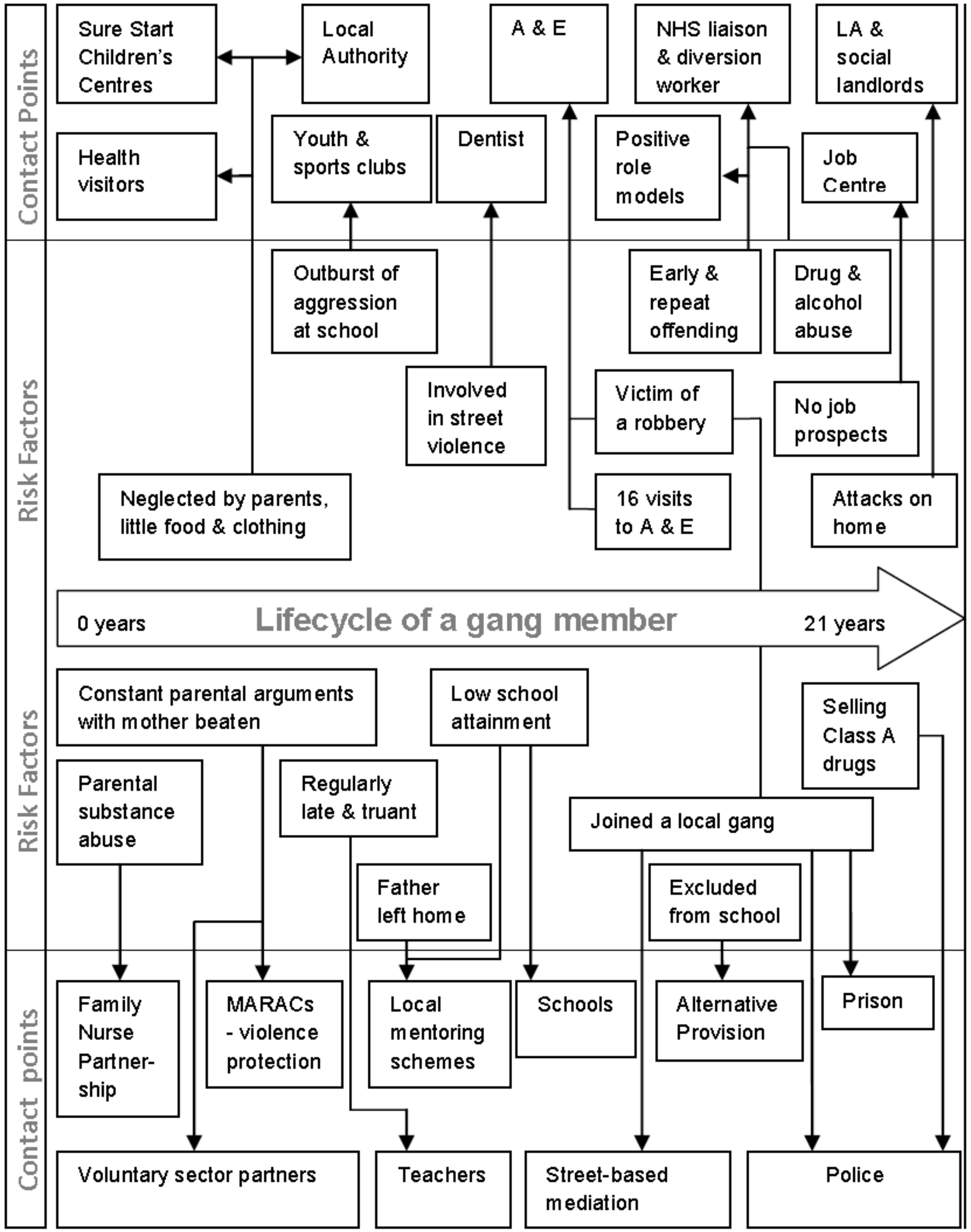


Fig. 8. The lifecycle of a gang member (Source: HMG: Ending Gang Youth Violence [13]).

The lifecycle of a gang member

Hypersimplices:

$\langle$regularly late and truant, school low attainment, excluded from school; $R_{experienced\_10\text{-}15}$ $\rangle$

precursor to

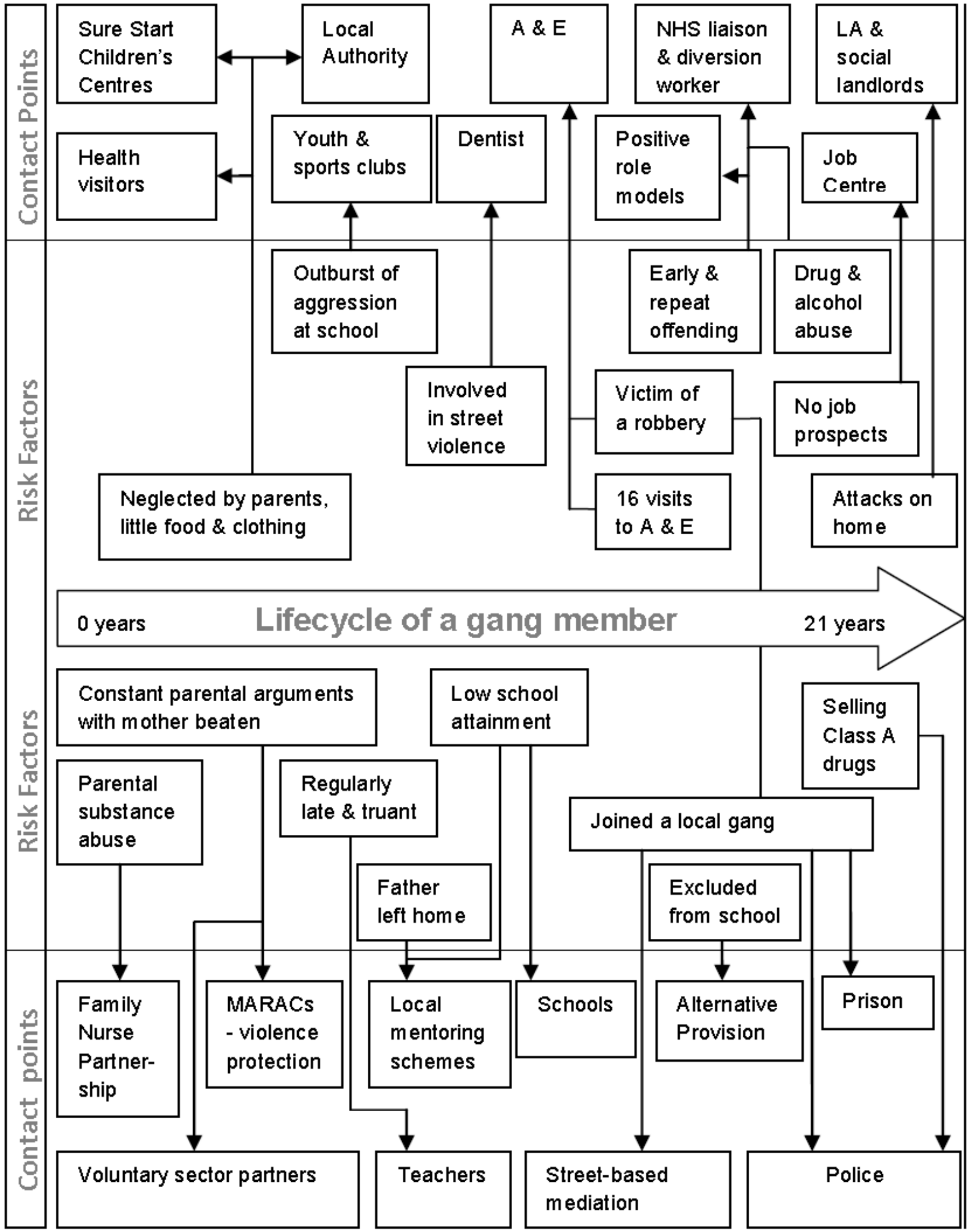
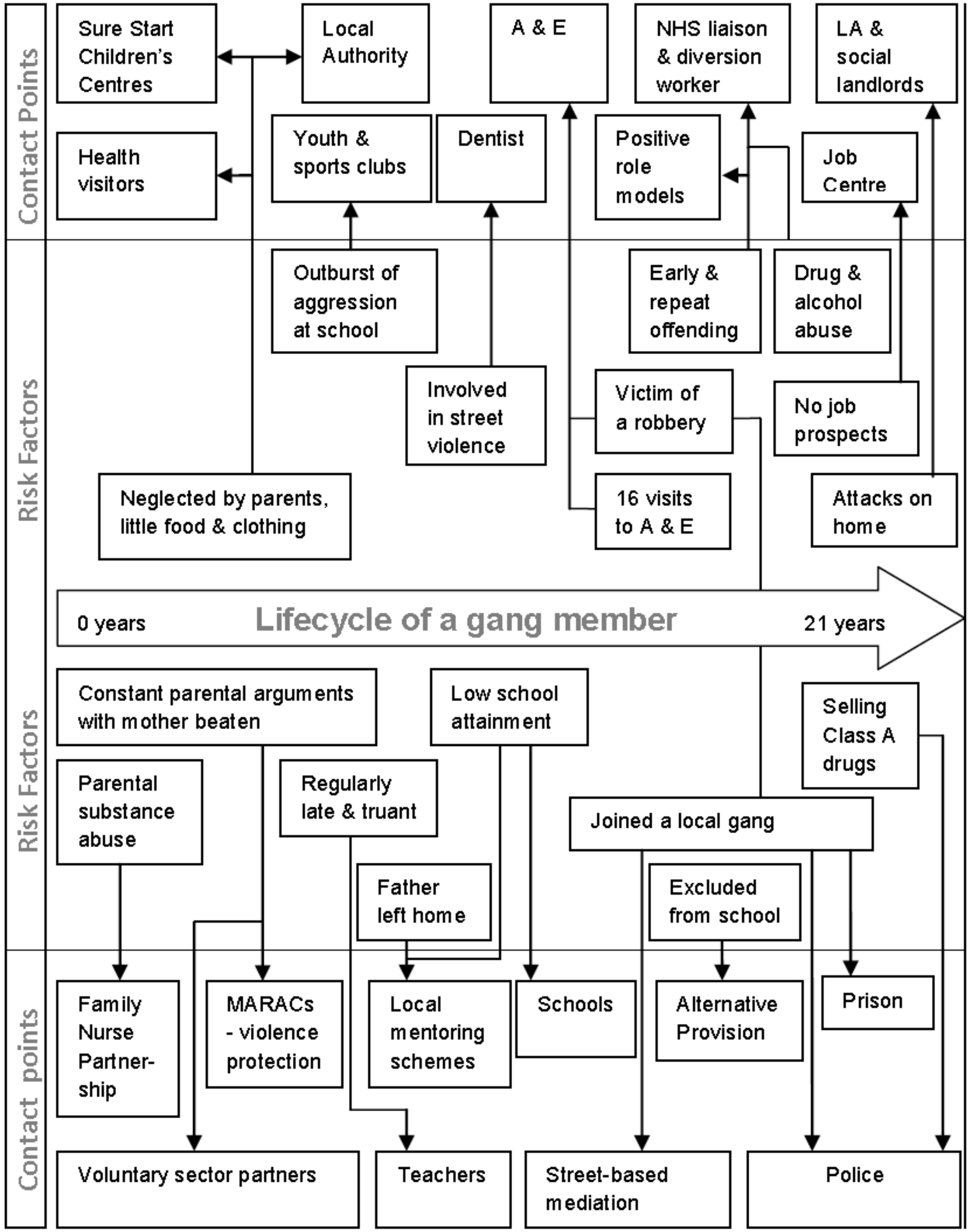


Fig. 8. The lifecycle of a gang member (Source: HMG: Ending Gang Youth Violence [13]).

The lifecycle of a gang member

Hypersimplices:

⟨joined a local gang,
selling Class A drugs,
early and repeat offending,
drug and alcohol abuse;
$R_{experienced\_16\text{-}21}$ ⟩



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The lifecycle of a gang member

Hypersimplices:

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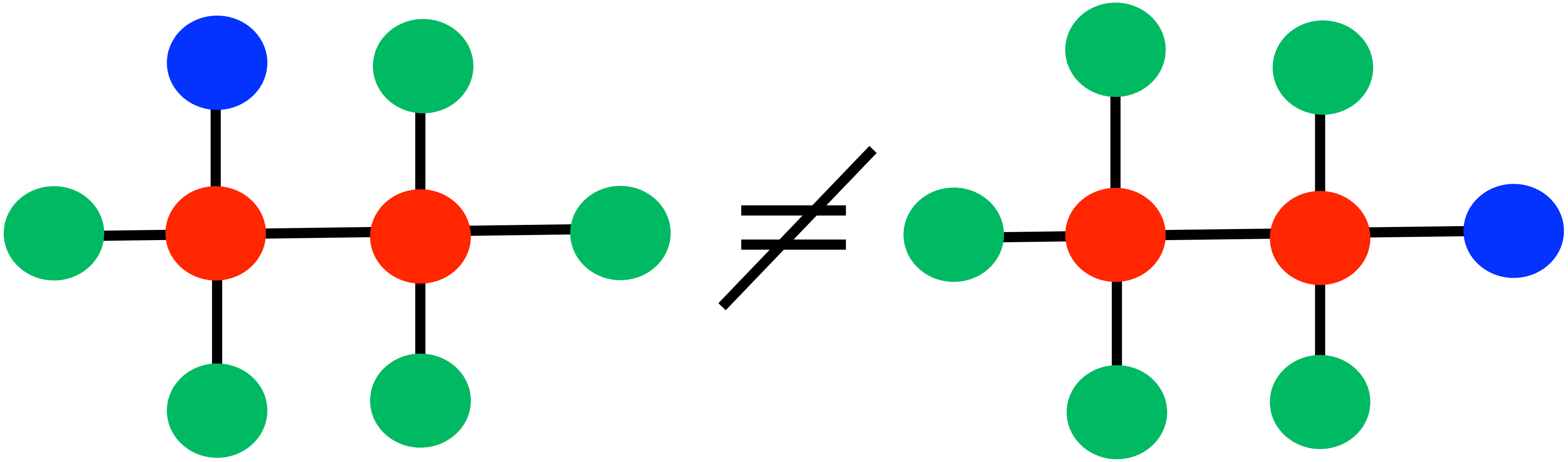
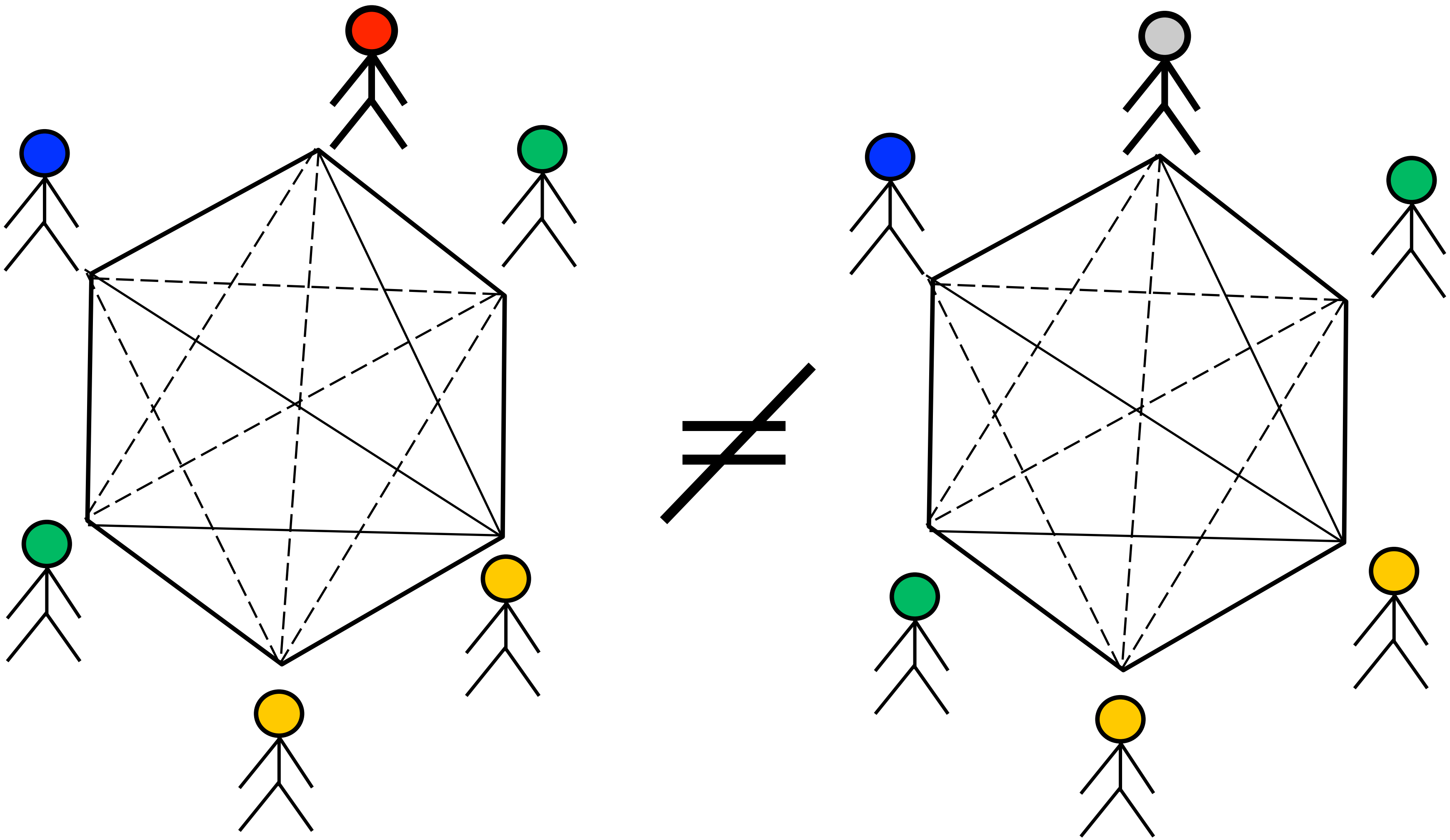
precursor to murder

Social Chemistry



In chemistry the relational structure of the atoms matters

Social Chemistry



In ~~chemistry~~ the relational structure of the atoms matters

social systems

Social Chemistry

$\sigma(731)$ = <gaming, sport, painting, literature, science, nature, history>
$\sigma(737)$ = <painting, literature, gardening, cooking, nature, science>
$\sigma(742)$ = <gaming, cooking, nature, science>
$\sigma(746)$ =<pubs, painting, history, literature>

Disconnected !

$\sigma(747)$ =<clothing, basketball, war history, graffiti, racing, mathematics>
$\sigma(753)$ =<pubs, sport, fashion, painting, history, cooking, nature, science>
σ (754) = <gaming, pubs, history, nature, science>
$\sigma(779)$ = <gaming, pubs, history, cooking, science>
$\sigma(760)$ = <gaming, painting, history, nature, science>
$\sigma(764)$ = <sport, painting, history, literature, cooking, nature, science>
$\sigma(767)$ =< sports, fashion, cooking, nature, science>
$\sigma(768)$ = <gaming, history, literature, cooking, science>
$\sigma(769)$ = <gaming, sport, cars, history, science, cooking>
$\sigma(770)$ = <sport, history, nature, science>
$\sigma(774)$ = <fashion, cooking, nature, science>
$\sigma(772)$ = <science>

In ~~chemistry~~ the relational structure of the atoms matters

social systems

Conclusions

Networks - essential for analysing social systems & policy

system behaviour emerges from interaction of pairs

network is the backcloth to traffic dynamics

networks are necessary for complex systems science

Hypernetworks also essential for social systems & policy

system behaviour emerges from *n*-ary interactions

hypernetworks are backcloth to ML traffic dynamics

hypernetworks - necessary for Global System Science