Very Large Scale Agent Based Simulation

Cognitive Decision Making

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Kaprun Gletscherbahn

Challenge: Perceptual Overload in Emergency Situations

Kaprun, November 11, 2000 (11 out of 161 survived)

Evacuation in Emergency Situations

- limited / no sight
  = inefficiency of visual signs
  (exit signs, directions, maps)
- high level of noise
  = inefficiency of auditory cues
  (speakers, announcements)
- “panic”
  = limited attentiveness
  (“usual” rationale of thinking / behaviour dominated / replaced by sudden fear)
- crowd dynamics
  = “mindless follower”
  (individual planning replaced by “trust” in crowd behaviour)

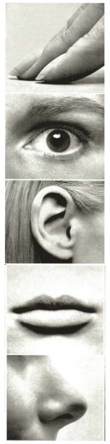
SOCIONICAL (EU FP7, FET proactive)

Understanding Complex (Socio-Technical) Systems

Duisburg, July 24, 2010 (18 civilians died)

London, July 7, 2005 (52 civilians died)

Haptic Displays: Perception and Cognitive Overload



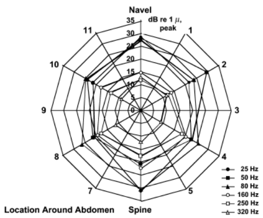
Visual:	10.000.000 bit/s	ca. 70-80%
Auditory:	1.000.000 bit/s	ca. 10-15%
Haptic:	400.000 bits/s	ca. 8-9%
Olfactory:	5000 bit/s	ca. 0.5%
Gustatory:	1000 bit/s	ca. 0.5%

“Cognitive Overload”: 12.000.000 bit/s <> 16 bit/s

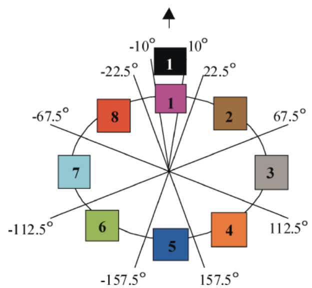
Perception Memory	max16 bit/s
Short Term Memory	max 0,5-0,7 bit/s
Long Term Memory	max 0,05 bit/s

Potentials of “Haptic Displays”

- avoid drawing **continuous focused attention** (“subliminal perception”)
- stimulus locations on the body directly mapped in self-centered frame of reference
  >> directional guidance
- extend bodily experience beyond the physical limits of the torso
  >> feeling at a distance

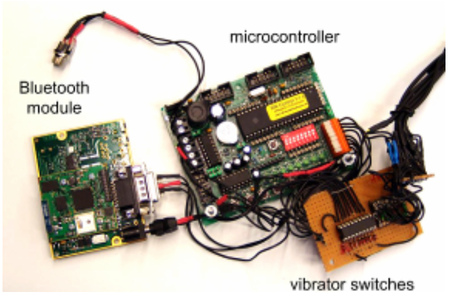


Roger W. Cholewiak, J. Christopher Brill, A. N. J. A. Schwab: Vibrotactile localization on the abdomen: Effects of place and space. Perception & Psychophysics, Vol. 66, No. 6. (August 2004), pp. 970-987.



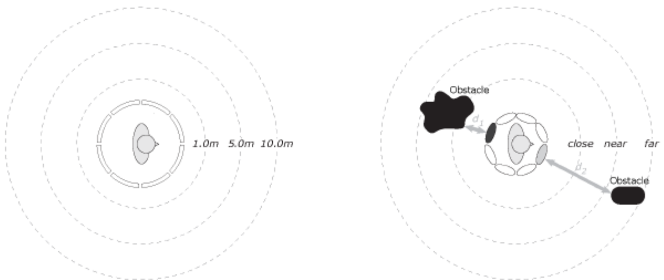
Van Erp, J. B. F., Van Veen H. A. H. C., Jansen, C., and Dobbins, T.: Waypoint navigation with a vibrotactile waist belt. ACM Trans. Appl. Percept. 2, 2 (April 2005), 106–117.

LifeBelt: Silent Directional Guidance based on Vibrotactile Stimulation

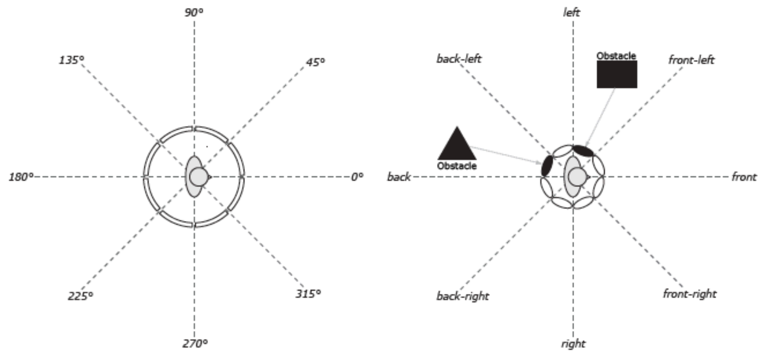


tactor elements — micro controller — belt system — body worn belt system

variation of (i) frequency, (ii) attenuation, (iii) mode



Notifying Distance: location + attenuation



Notifying Orientation: location + frequency

A. Ferscha, B. Emsenhuber, A. Riener, C. Holzmann, M. Hechinger, D. Hochreiter, M. Franz, A. Zeidler, M. dos Santos Rocha, C. Klein: Vibro-Tactile Space-Awareness. 10th International Conference on Ubiquitous Computing (Ubicomp 2008), 2008.

LifeBelt: Silent Directional Guidance for Crowd Evacuation

(A "Typical" SOCIONICAL) Research Question

> *"Can vibrotactile displays for directional guidance improve the efficiency of the evacuation process of crowds from emergency situations?"*

Approach

- Compare the effectiveness of LifeBelt supported vs. non supported evacution from closed spaces (with multiple exits)
- Evidence based simulation: Discrete event (floor field) simulation analysis of evacuation process based on individual behaviour
- Compare strategies of next step behaviour recommended to individuals in panic

- LifeBelt serves several purposes:
  - Collect "local context/behavior" (position/orientation/vicinity sensors)
  - Disperse "local view" of sensed data (vicinity/background)
  - Receive recommendations from background system
  - Acts as a local vibrotactile navigational guidance device

A Floor Field Simulation based Evacuation Model

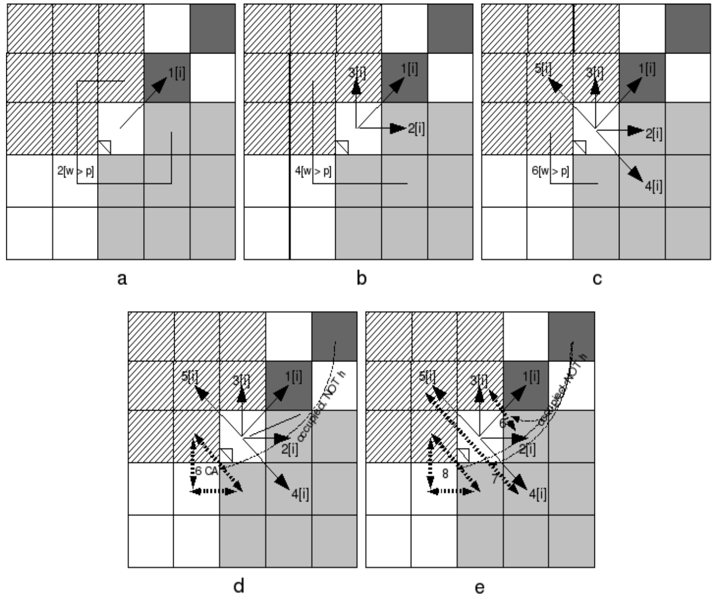
Case 1: step 1 = If cell ahead is empty, instantaneously move to the cell. Otherwise apply step 2. Step 2 = Choose a random empty cell from remaining cells (indicated by partial square), but if and only if w (wait) is greater than p (patience). Else wait.

Case 2: similar to case 1 except that a cell relatively closer to the destination (front-right or front-left) is chosen in step 2 and 3. Random choice step degrades to step 4 applied to lesser number of cell.

Case 3: is further extension of case 2 in which cell at right or left is also considered if steps 2 and 3 fail. The choice of cell at ±90º is a counter-productive choice, particularly when DOM is exactly diagonal to cell but in most of the cases this is a neutral choice. Individuals experiencing a jam always adopt a sideways movement in normal circumstances. Case 3 is a benchmark which can be considered as the normal human behavior without panic. This is the behavior that would most probably be adopted by an individual in dark, if he is not wearing belt (probing forward and sideways with hands before making a move).

Case 4: if steps 1 to 5 fail, a congestion avoidance mechanism is applied to choose between two candidate cells (indicated by thick dashed lines with double arrow head). The congestion avoidance mechanism is only applied if cell ahead of cell ahead is occupied (indicated by dashed elliptical line), and both comparative cells are empty. If one of them is empty, the individual just moves to that cell. If both of them are occupied, the individual moves to the previous cell (in backward direction), if waiting has exceeded the patience level, otherwise the individual waits.

Case 5: is a special case of case 4 in which CAM is applied for each pair of comparative cells.



Cellular Automaton
(Patience enhanced Moore Model)

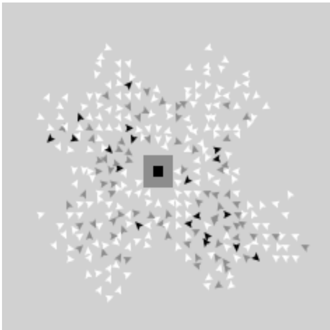
each individual can only move to a nearby cell In one (discrete) time step based on transition probabilities derived from:

i. direction of motion (e.g. SP towards exit)
ii. interactions with other individuals
iii. interactions with the structure

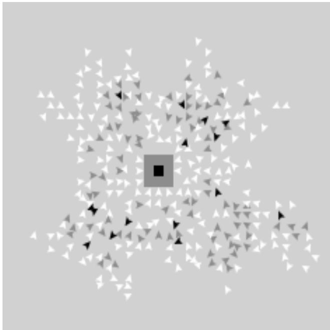
LifeBelt: Dynamics of Panic in Single Exit Scenarios

Center Exit

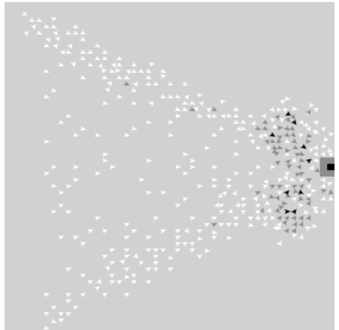
Side Exit



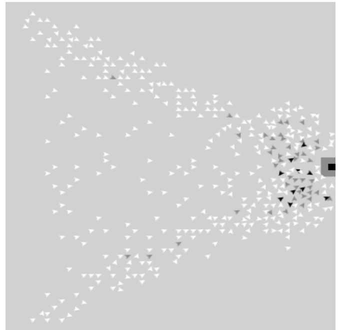
Center exit, without congestion avoidance



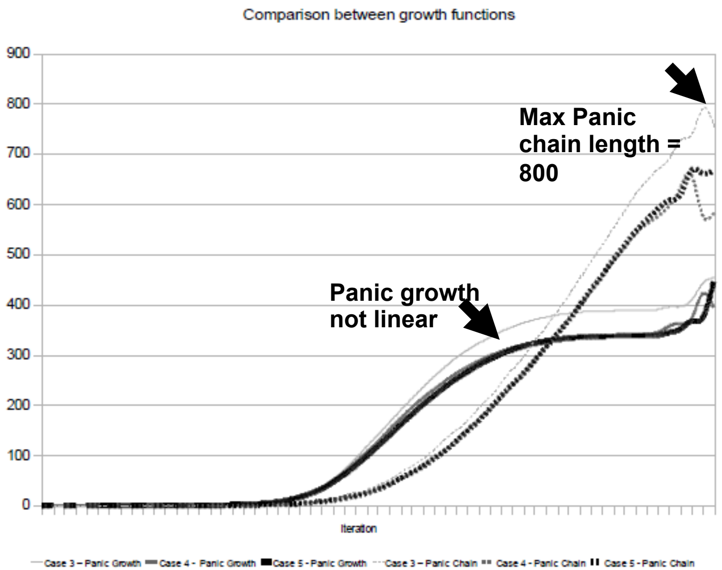
Center exit, with congestion avoidance

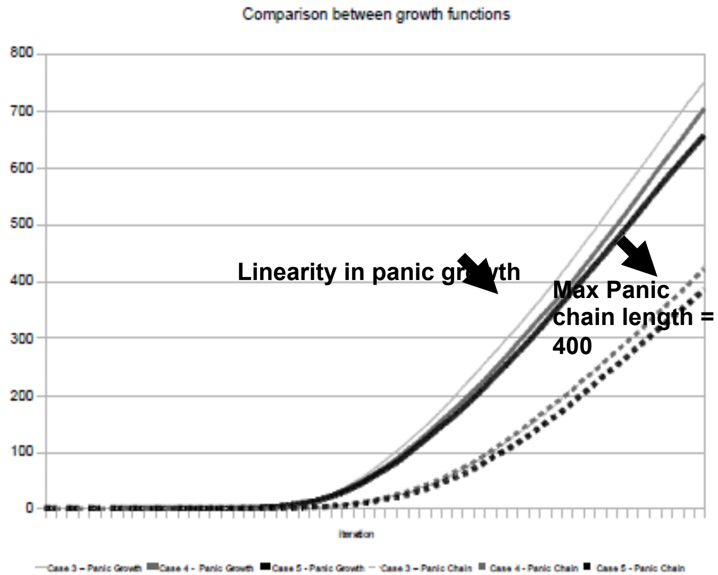


Side exit, with congestion avoidance



Side exit, with congestion avoidance





LifeBelt: Exit Recommendations in Multiple Exit Scenarios

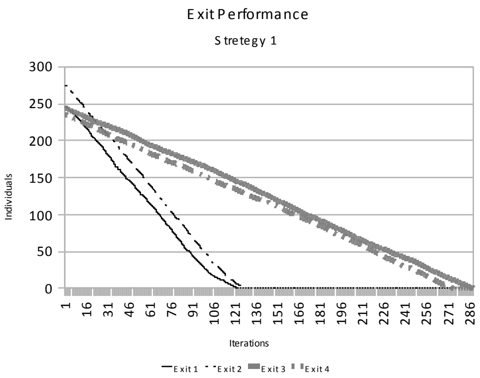
$$PET_i = TEA_i + (EP_i / EC_i)$$

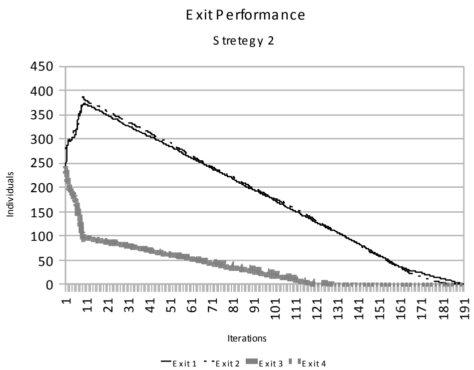
PET_i	predicted exit time at exit i.
TEA_i	time to reach to exit area (EA) i.
EC_i	exit capacity of exit i.
EP_i	exit population at exit i (strategy 2), exit panic at exit i (strategy 3).

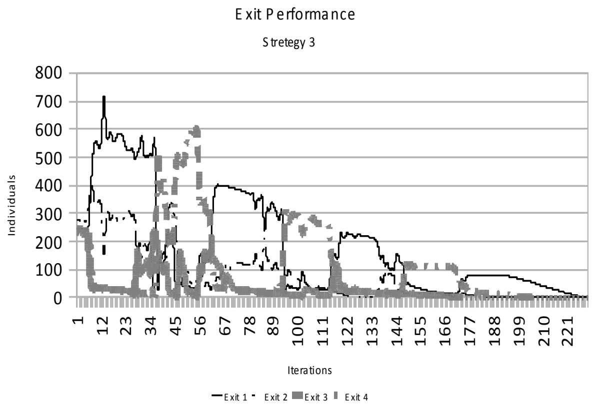
Strategy 1:
Nearest Exit

Strategy 2:
Exit Area Density

Strategy 3:
Effective Exit Area Throughput

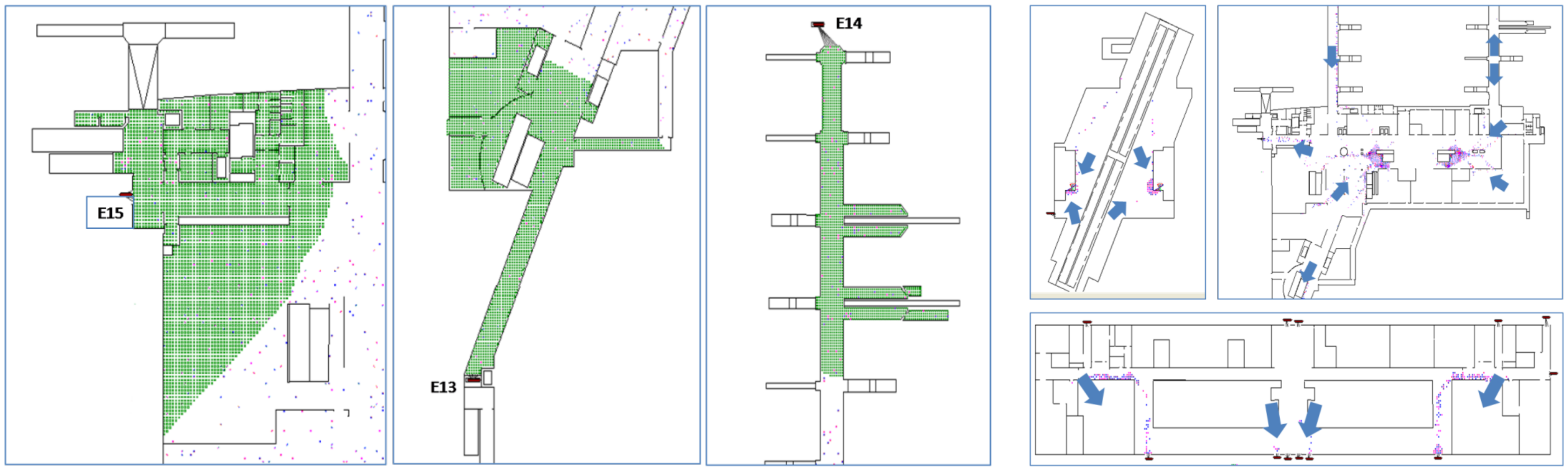






Ferscha, A., Zia, K.: On the Efficiency of LifeBelt based Crowd Evacuation. In: Proceedings of 13th IEEE/ACM International Symposium on Distributed Simulation and Real Time Applications (DS-RT 2009), IEEE 2009.

Empirical Trust: Evacuating ÖBB Linz Main Station



A. Ferscha , K. Zia: “LifeBelt: Silent Directional Guidance to improve Evacuation Efficiency”. IEEE Pervasive Computing, Oct-Dec 2010.

Empirical Trust: Evacuating ÖBB Linz Main Station

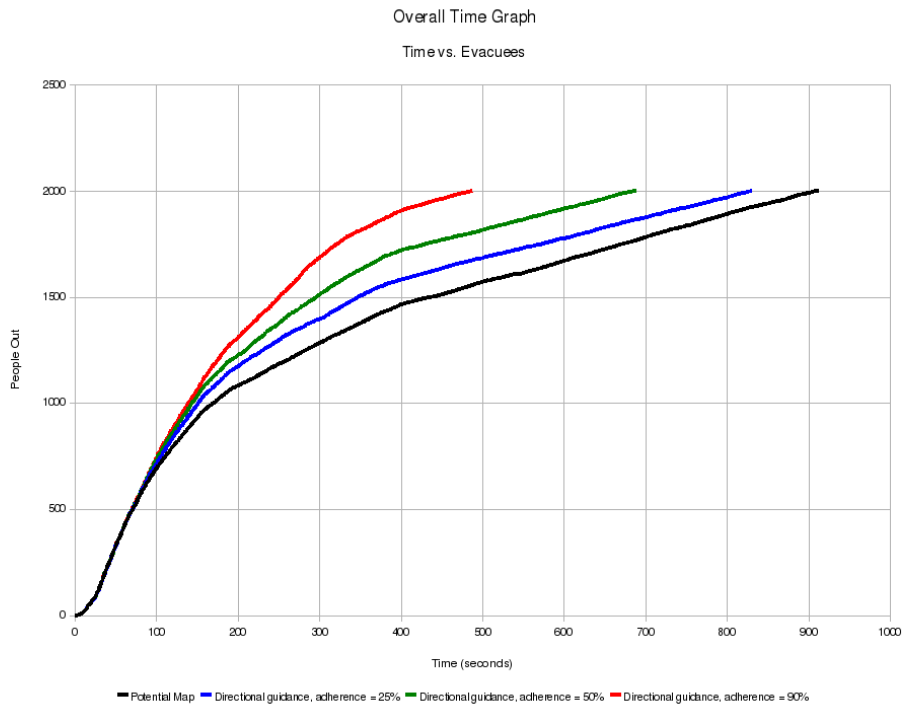
Evacuee gets a directional command by the belt (redirect at 10, 30, 80% of the way)

Test on decision making: adhere, ignore

Experiment: 42 test runs with variation of starting-, redirection points, crowd stimulus

- In 37 runs (88,1%), test persons trusted the LifeBelt (correct redirection)
  - In 3 runs persons hesitated before redirection
  - 2 persons noted that they trusted the LifeBelt in this experimental scenario; however, they wouldn't in a real panic/evacuation situation
- In 5 runs, test persons (11,9%) did not trust the LifeBelt (ignore redirection command)
  - In 2 out of these 5 cases: test person is a fire fighter, run immediately to the next exit
  - Independent from crowd stimulus (40% vs. 60%)

Simulation Results



Red line: the most efficient evacuation where adherence is 90%

A. Ferscha , K. Zia: "LifeBelt: Silent Directional Guidance to improve Evacuation Efficiency". IEEE Pervasive Computing, Oct-Dec 2010.

Computational Trust: Decision Making in MAS (for Evacuation)

Trust is an attitude of an agent towards an **information source (s)** that determines the **extent** to which **information received** by the agent (r) from s **influences r's belief(s)**

Decision making model needs to reflect:

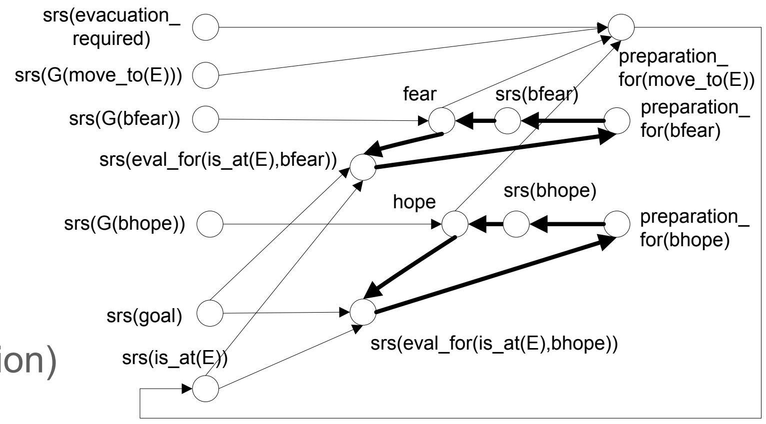
Intentions: trust towards neighboring agents and belief for options (exits)

Emotions: fear for options, hope for options and resulting attraction for options

Individualism: expressiveness, openness and contagion

Decision making in MAS based on:

- R's **individual** characteristics
- R's current **belief(s)** on available options
- R's trust on **neighborhood**
- **Beliefs** of **neighborhoods** (R's perception)
- **Emotional status** of **neighborhood** (R's perception)



Decision making model for an agent to move to exit E

[1] S.P. Marsh, Formalising trust as a computational concept. PhD thesis, Department of Mathematics and Computer Science, University of Stirling, 1994.
[2] Deutsch, M.: Cooperation and Trust: Some Theoretical Notes. In: Nebraska Symposium on Motivation. Nebraska University Press. (1962)
[3] Luhmann., N.: Familiarity, Confidence, Trust: Problems and Alternatives. In: Trust: Making and Breaking Cooperative Relations. Department of Sociology, University of Oxford (2000)
[4] Barber, B.: Logic and Limits of Trust. Rutgers University Press (New Brunswick, N.J.) (1983)
[5] Gambetta, D.: Can We Trust Trust? In: Trust: Making and Breaking Cooperative Relations. Department of Sociology, University of Oxford. (2000) 213-237
[6] A. Sharpanskykh, K. Zia, Grouping behaviour in AmI-enabled crowd evacuation, Proceedings of the 2nd International Symposium on Ambient Intelligence, ISAmI'10, Springer, 2011.

Computational Trust: Cognitive Decision Making in MAS

Temporal State Transition Model for Affective Decision Making

1. **Aggregate emotions** of neighbors (n) for all possible exits (e): Actors → all AmI-assisted agents (a)

$$gX = (gX + (trust_a(n) \times X_e)) \div count(n)$$

Where X represents fear, hope and attract

2. **Update intentions** of neighbors (n) for all possible exits (e) : Actors → all AmI-assisted agents (a)

$$belief_n(e) = belief_n(e) + trust_n(a) \times (belif_a(e) - belief_n(e))$$

$$trust_n(a) = trust_n(a) + belief_a(optExit) \times (1 \div (1 + (10^{-x}(1 - (belief_n(optExit) - belief_a(optExit))) + 4))) - trust_n(a)$$

Where "optExit" is chosen exit; and "x" is 39 (AmI neighbor) or 9 (neighbor)

3. **Update emotions: individual**: Actors → all agents (a)

$$hope_a(e) = (bhope_a - bhope_a \times (1 - ghope) \times)(1 - a4) + (1 - bhope_a) \times ghope \times a4 \div (1 - bhope_a \times (1 - ghope) \times a3 -)(1 - bhope_a) \times ghope \times a3$$

Where a1 = dist = $belief_a(e)$, a2 = 1 – dist, a3 = ($bhope_a$ × a2) + a1 − ($bhope_a$ × a1), and a4 = $bhope_a$ − ($bhope_a$ × a2)

$$fear_a(e) = (bfear_a - bfear_a \times (1 - gfear) \times)(1 - a4) + (1 - bfear_a) \times gfear \times a4 \div (1 - bfear_a \times (1 - gfear) \times a3 -)(1 - bfear_a) \times gfear \times a3$$

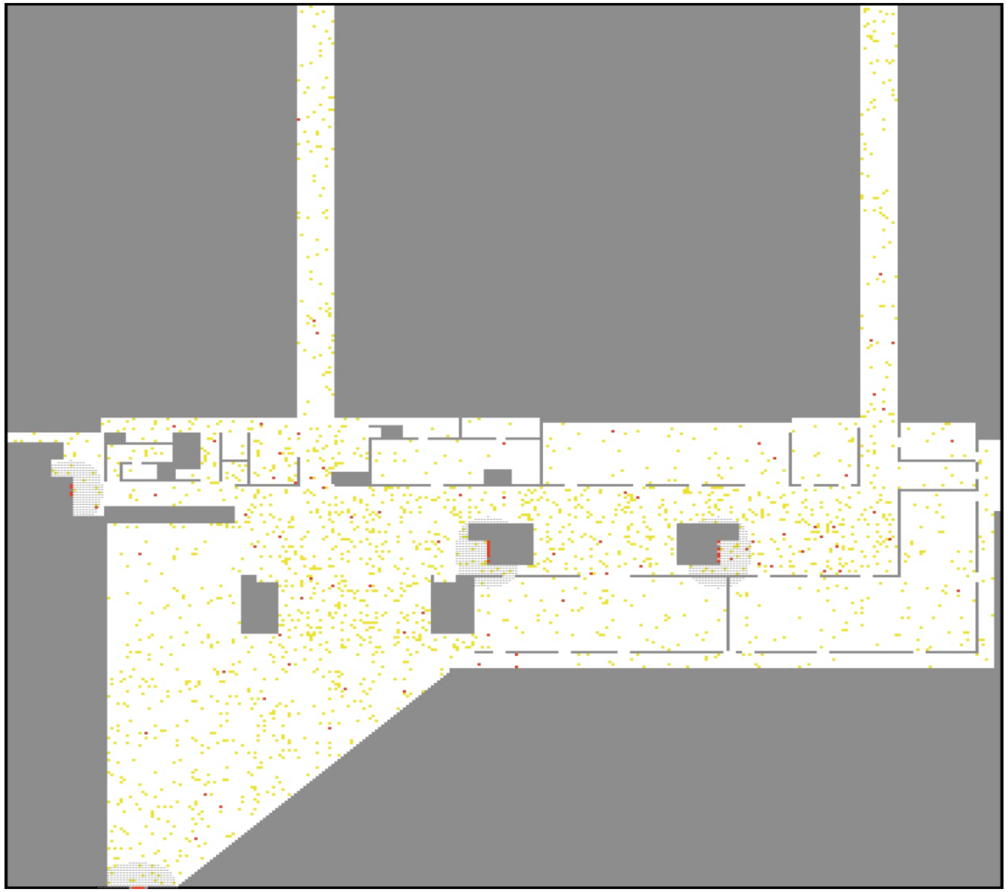
Where a1 = a2, a2 = a1, a3 = ($bfear_a$ × a2) + a1 − ($bfear_a$ × a1), and a4 = $bfear_a$ − ($bfear_a$ × a2)

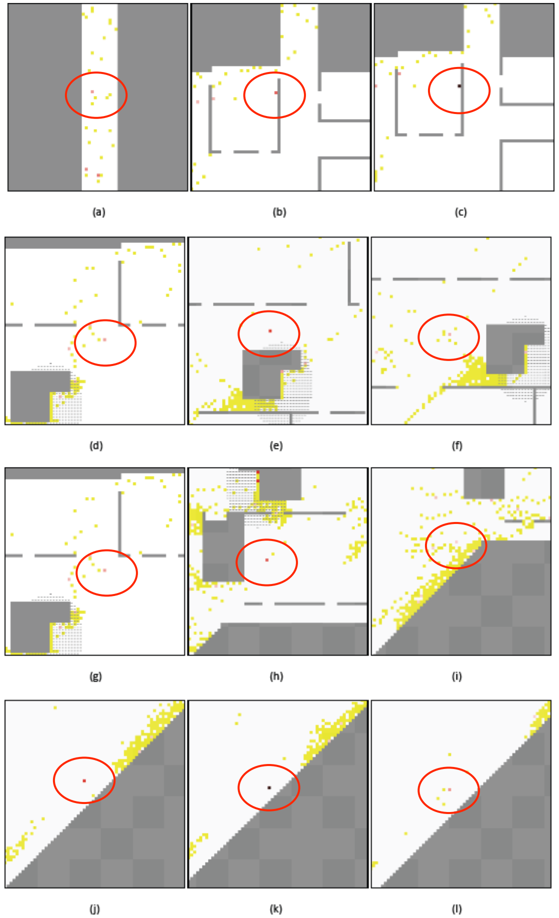
$$attract_a(e) = attract_a(e) + (gamma \times (battract_a \times (1 - ((1 - hope_a(e)) \times fear_a(e) \times (1 - gattarct))) + (((1 - battract_a) \times hope_a(e) \times (1 - fear_a(e)) \times gattract) - attract_a(e)$$

Where bhope, bfear and battract are individual emotions character of agents, and gamma is a "trust in technology" constant.
The exit with max. attraction would be chosen exit.

Computational Trust: Evolution of Trust

Trust of neighborhood (normal) agents on (LifeBelt) assisted agents
(interaction range = 10 cells, device penetration=4%)



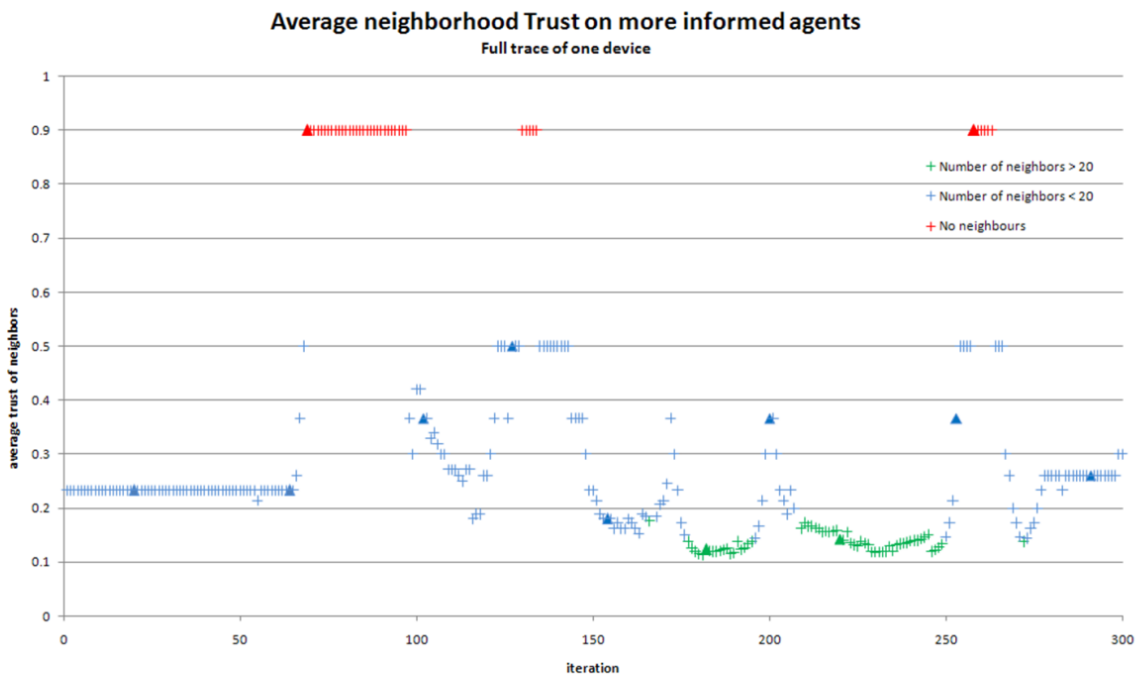


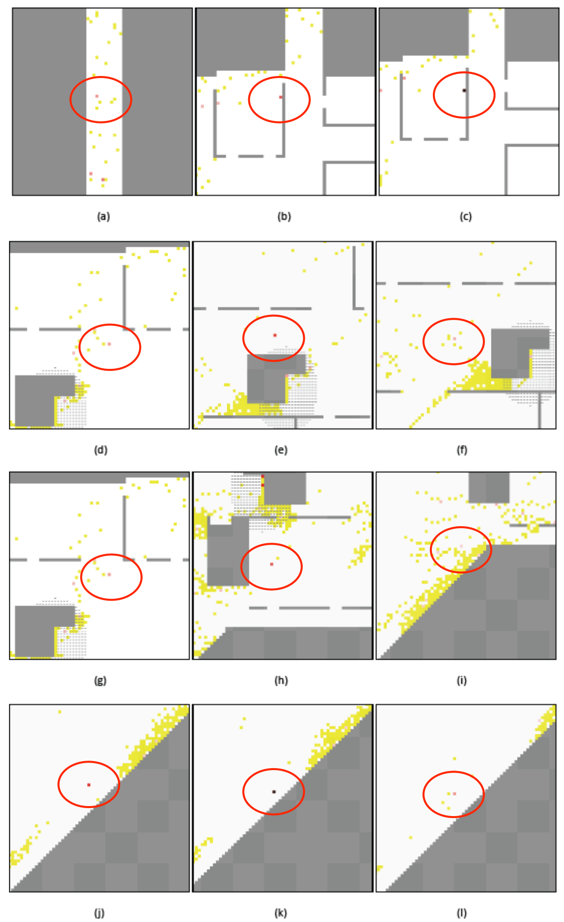
Average neighborhood trust on assisted agents (Red: Assisted agents, Yellow: Non-assisted)

A single instance of agent taken from video on Left

Computational Trust: Evolution of Trust

Trust of neighborhood (normal) agents on (LifeBelt) assisted agents
(interaction range = 10 cells, device penetration=4%)



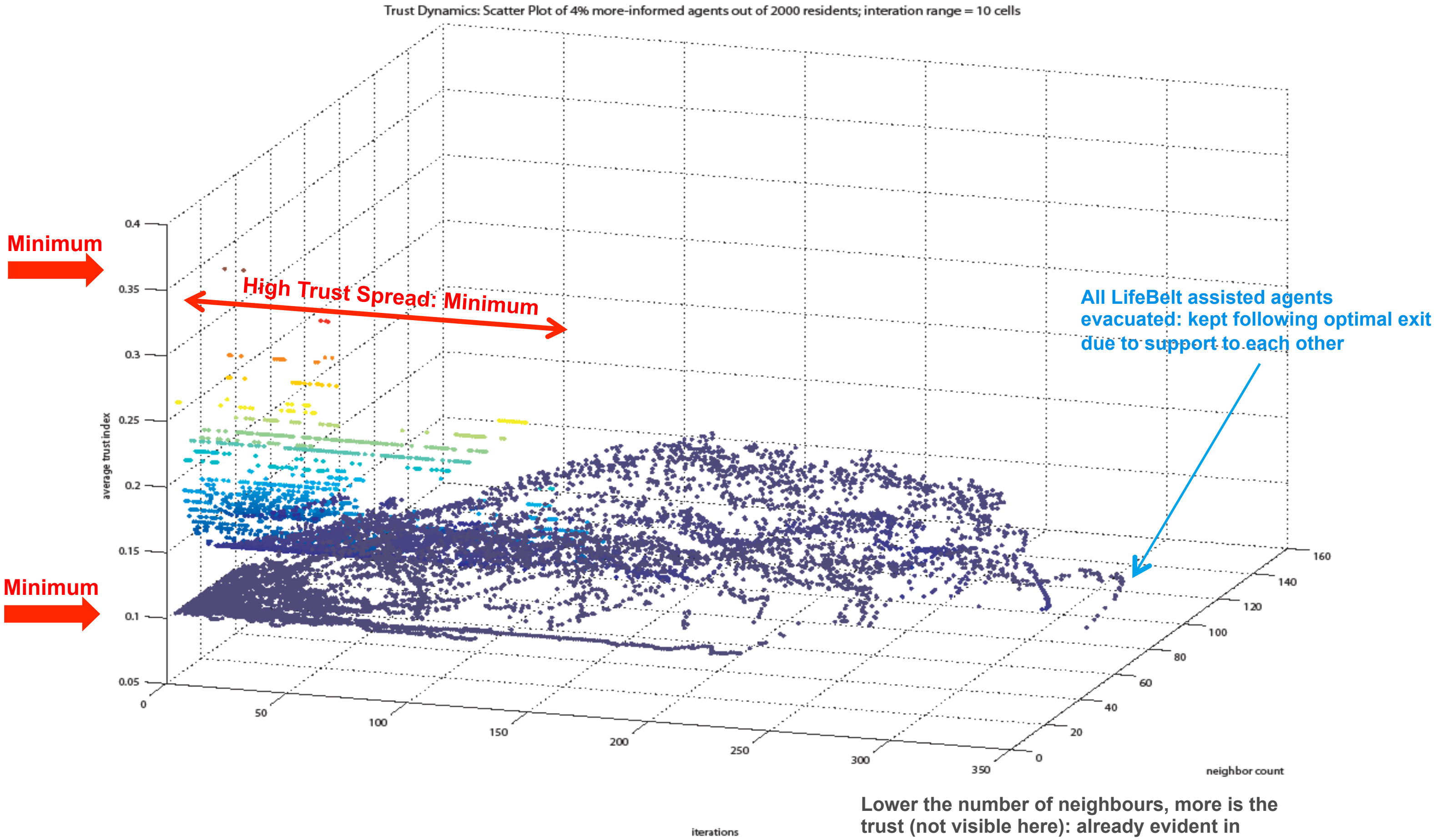


Results:

Trust of neighborhood on assisted agent increases with decrease in neighborhood density and v.v.

Computational Trust: Evolution of Trust

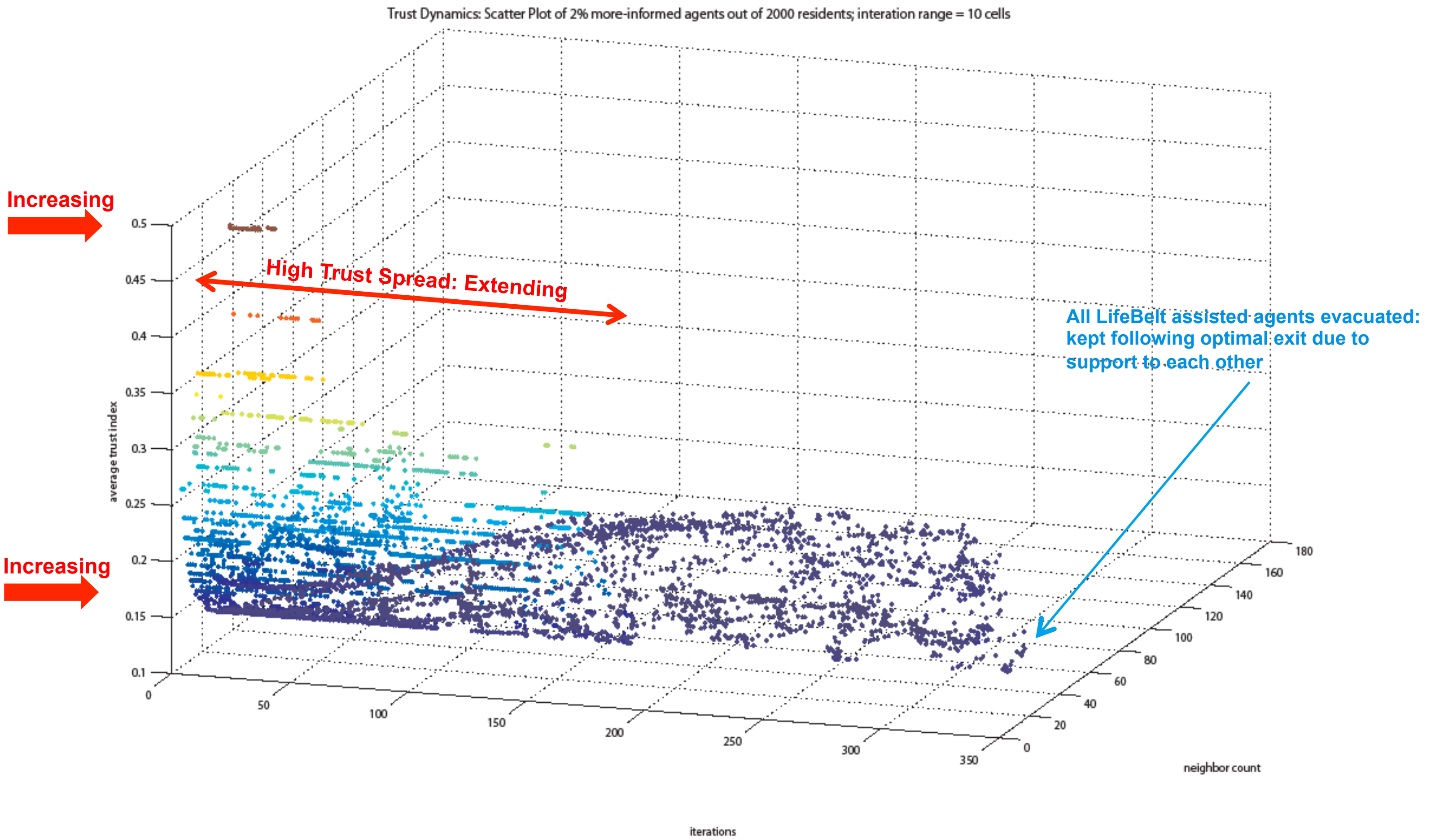
Case 1: interaction range = 10 cells, device penetration rate = 4%
Case 2: interaction range = 10 cells, device penetration rate = 2%
Case 3: interaction range = 10 cells, device penetration rate = 1%
Case 4: interaction range = 5 cells, device penetration rate = 1%



Lower the number of neighbours, more is the trust (not visible here): already evident in single AmI assisted agent graph

Computational Trust: Evolution of Trust

Case 1: interaction range = 10 cells, device penetration rate = 4%
Case 2: interaction range = 10 cells, device penetration rate = 2%
Case 3: interaction range = 10 cells, device penetration rate = 1%
Case 4: interaction range = 5 cells, device penetration rate = 1%



Computational Trust: Evolution of Trust

Case 1: interaction range = 10 cells, device penetration rate = 4%
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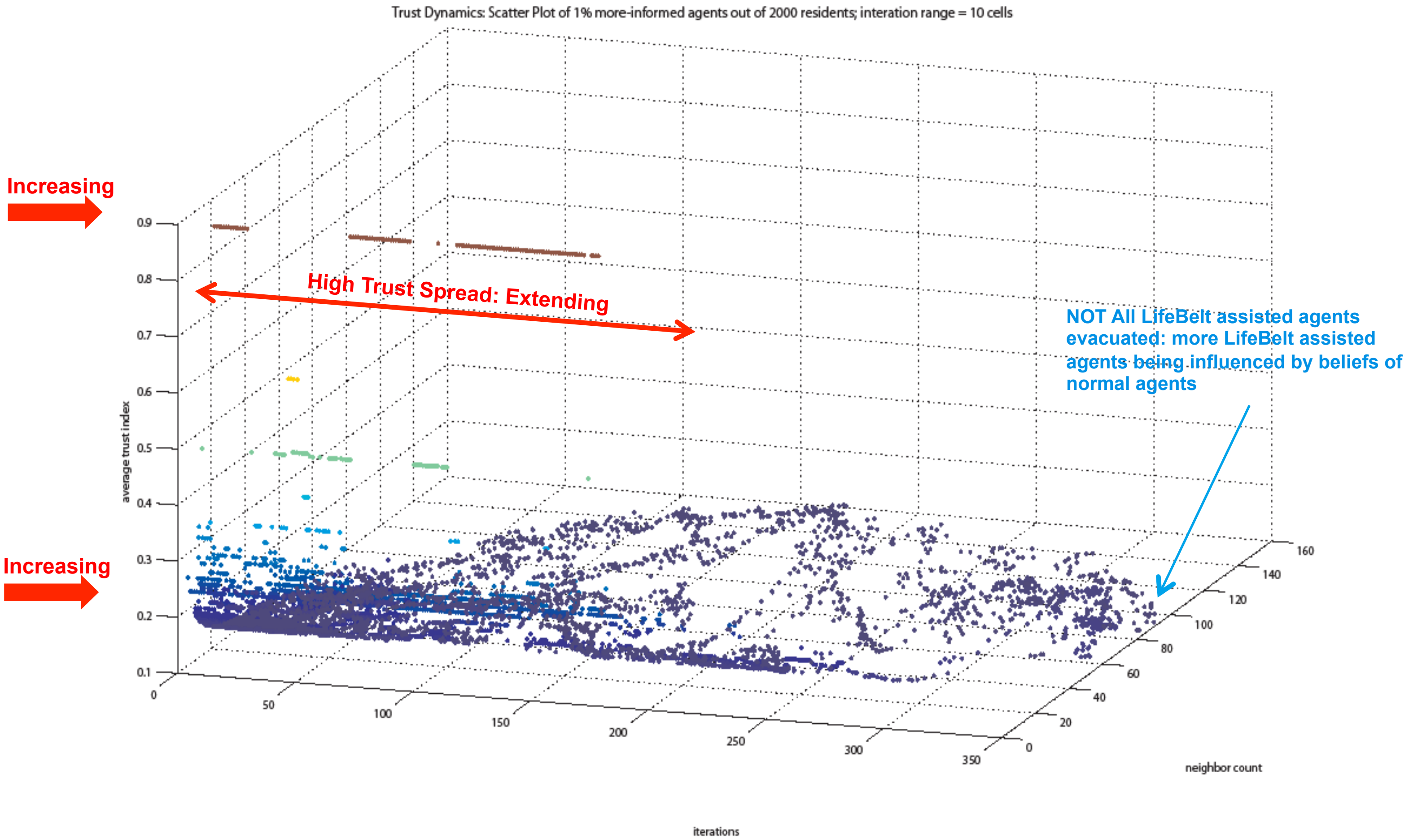

Computational Trust: Evolution of Trust

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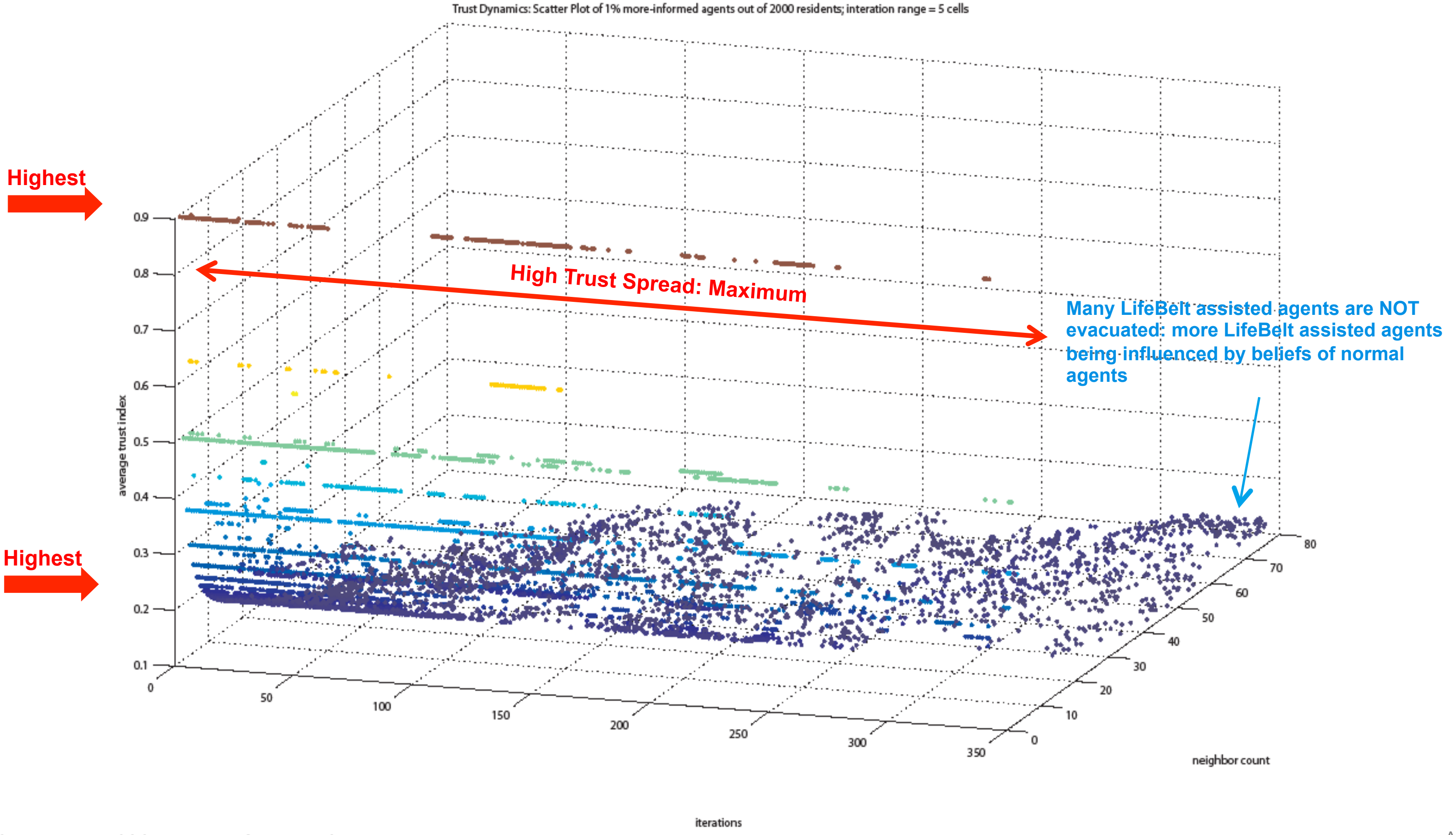

Computational Trust: Evolution of Trust

Case 1: interaction range = 10 cells, device penetration rate = 4%
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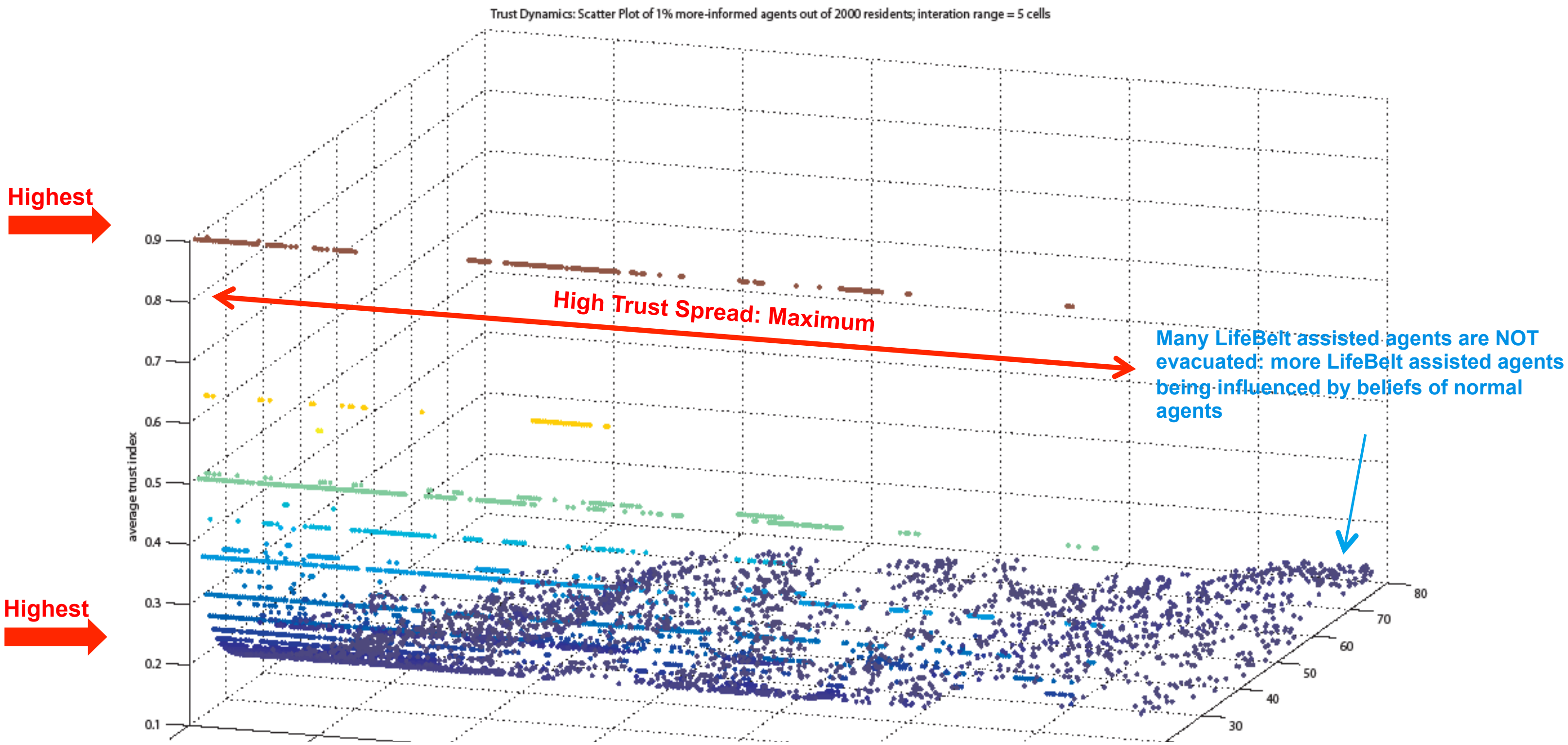
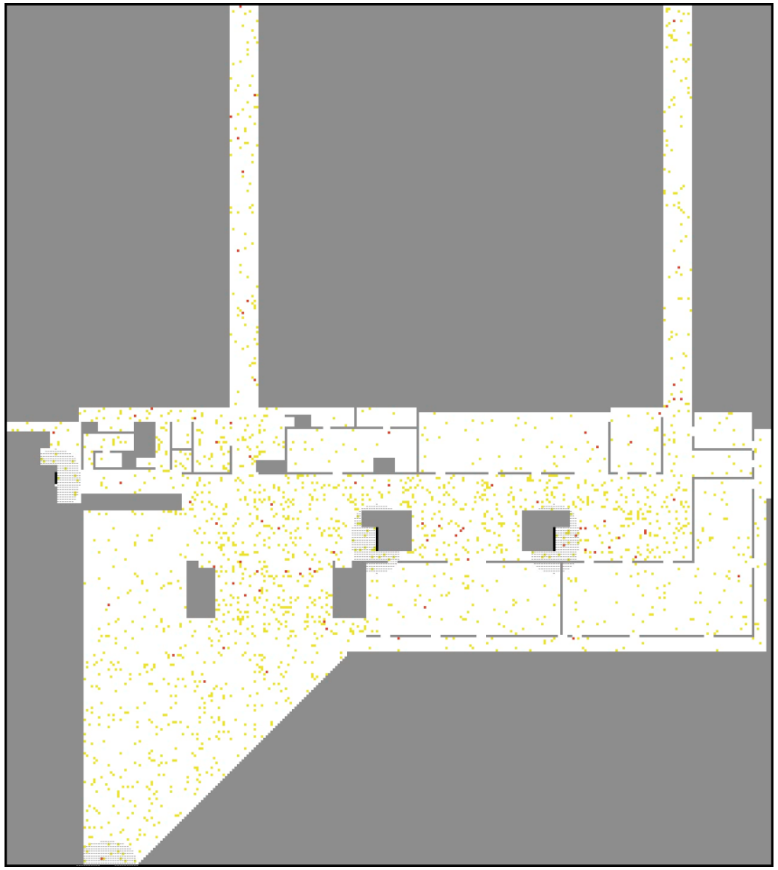


Results:

- With decrease in device penetration / interaction range, the resulting isolation (1) increases the trust of neighbours on the AmI assisted agents, (2) increases the spread of max. trust, (3) increases the max. and min. trust
- With decrease in device penetration / interaction range, the tendency of AmI assisted agents being influenced by normal agents increases (less probabability of assistive influence of nearby AmI assisted agents)

Computational Trust: Effect of Device Penetration Rate

- Case 1: All agents are LifeBelt assisted (black:assisted)
- Case 2: 4% of agents are LifeBelt assisted (black:assisted, blue:optimal, yellow:non-optimal)

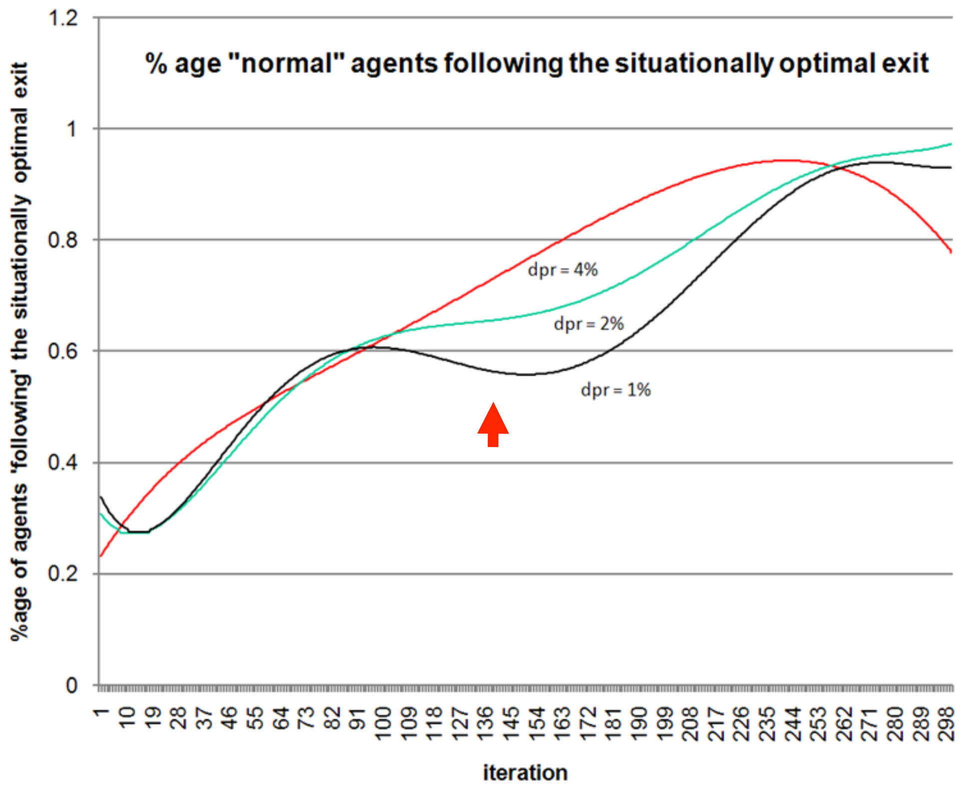


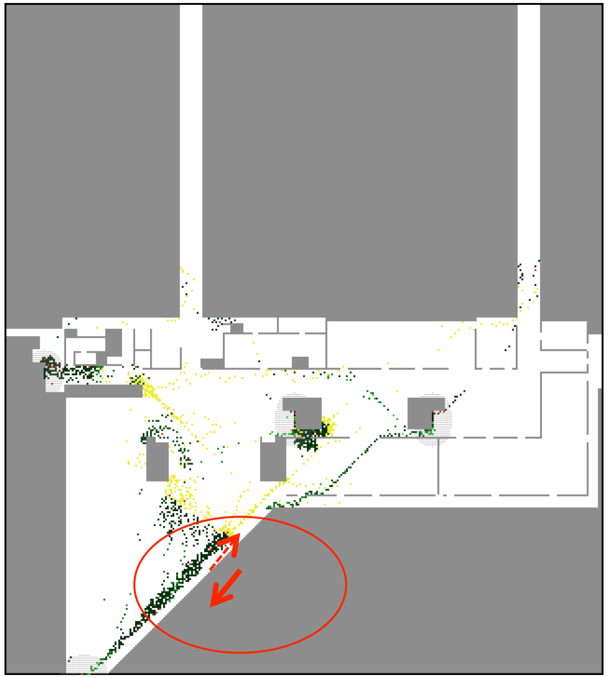
100% LifeBelt agents; **Agents evacuated after iteration 300: 96%**

4% LifeBelt agents; **Agents evacuated after iteration 300: 88%**

Computational Trust: Effect of Device Penetration Rate

- Case 1: All agents are LifeBelt assisted (AmI enabled)
- Case 2: (1,2,4)% of agents are LifeBelt assisted (AmI enabled)





2% AmI assisted agents, Sim screen at iteration 141: Many yellow agents are following the RED towards E13 (bottom), in spite of optimal exit for them being left staircase. Due to this the extent belief in system corresponding to optimal exit is on the lower side (see graph).

Results:

- **Remarkable "following" behaviour of non-assisted agents towards assisted agents.**
- **Assisted agents, although moving towards optimal exits themselves, change random intentions of non-assisted agents which may not be optimal for that agent.**
- **Evacuation efficiency is promising even with small % of AmI assisted ; 66%(dpr=1%), 81%(dpr=2%), 88%(dpr=4%), 96%(dpr=100%)**

Computational Trust: Emergence of Leadership

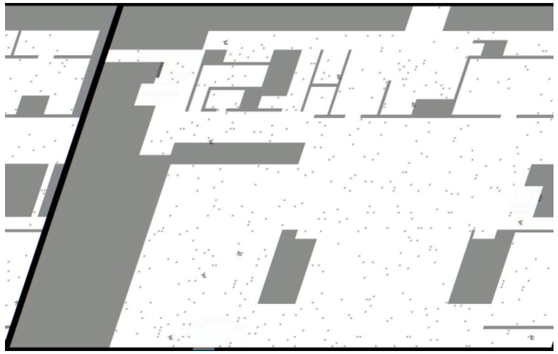
Emergence of leadership based on group trust

- Emotional decision making model for the option to move to exit E
- varying initial trust values, trust update intensity, and interaction range
- comparison of four cases: S1, S2, S3, S4

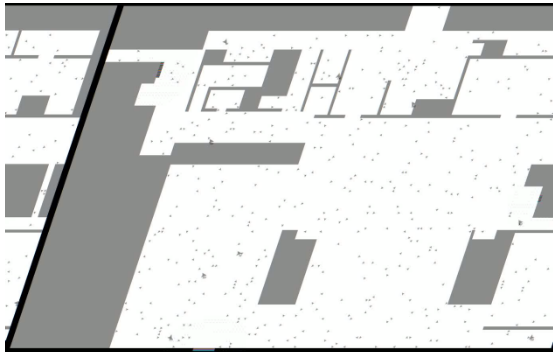
Simulation setting Parameter	S1	S2	S3	S4
Initial trust value to an AmI-enabled agent	0.9	0.1	0.9	0.9
Initial trust value to an agent without AmI	0.1	0.1	0.1	0.1
ω1 in the update of trust to an AmI-enabled agent	39	9	9	39
ω1 in the update of trust to an agent without AmI	9	9	9	9
Interaction range (in cells)	10	10	10	25
Evaluation metrics	**S1**	**S2**	**S3**	**S4**
Mean overall evacuation time (standard deviation)	147.7 (10.7)	174.4 (16.9)	150.1 (9.7)	170.3 (21.3)
Mean following index fi (standard deviation)	0.46 (0.09)	0.27 (0.12)	0.43 (0,07)	0.5 (0.09)
Mean change index ci (standard deviation)	0.48 (0.05)	0.25 (0.07)	0.92 (0.21)	0.17 (0.03)
Mean group size gs (standard deviation)	26 (8.7)	29 (19.8)	27 (8.3)	81 (14.2)

Results:

- **Leader-following behaviour**
- **The trust on AmI assisted agents in case of S1 and S3 is more than S2**
- **More Group changing in S3 than in S1**
- **Larger groups do not mean an efficient evacuation**



S2



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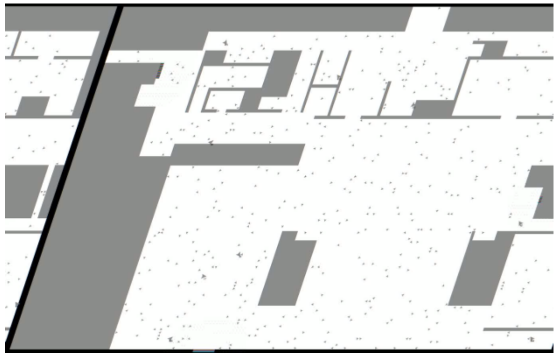
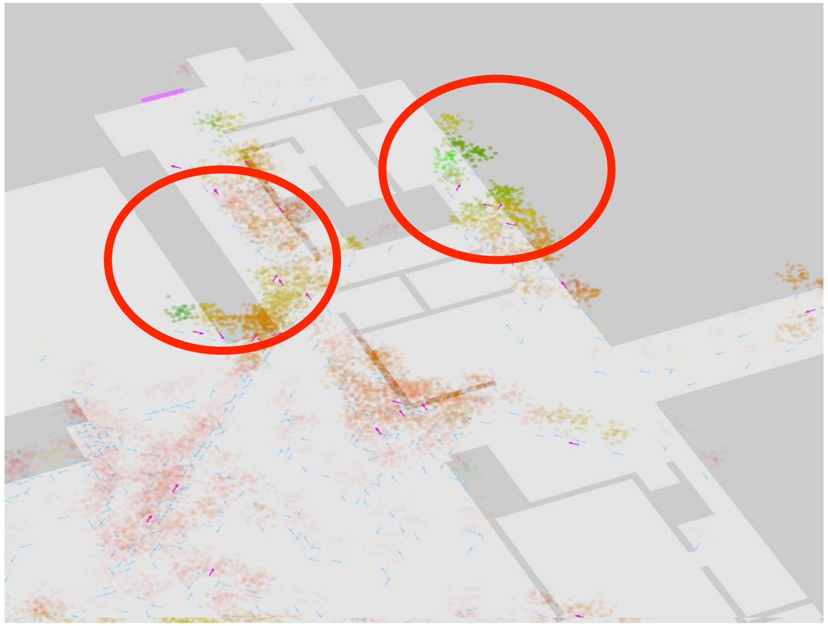


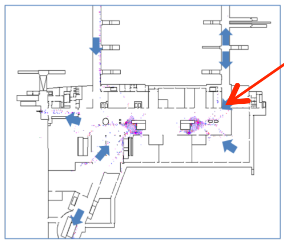
S4

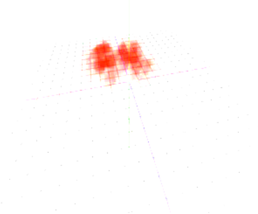
Visual Trust Analysis: Evacuating ÖBB Linz Mainstation



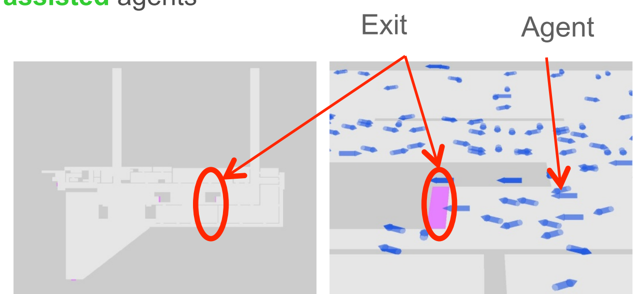
With **10% AmI-assisted** agents (purple)

With **0% AmI-assisted** agents

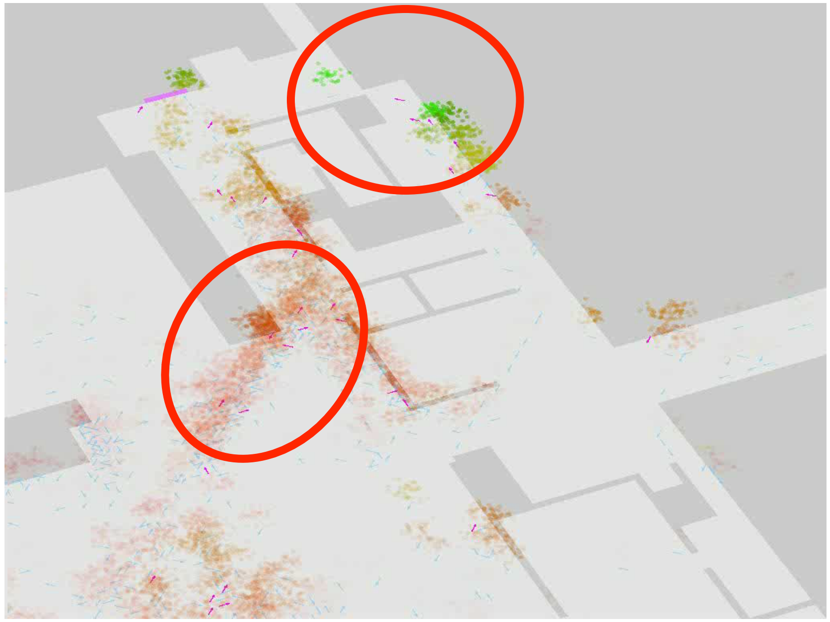




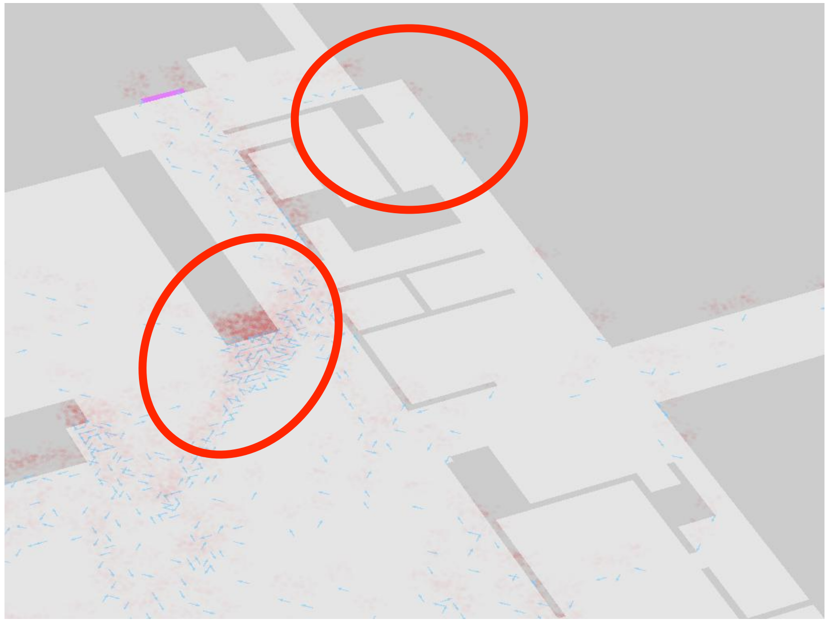
Trust: 0..red, 0.5..orange, 1..green



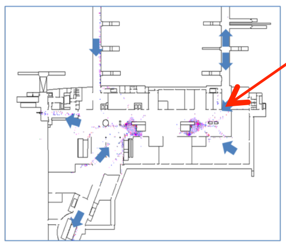
Visual Trust Analysis: Evacuating ÖBB Linz Mainstation

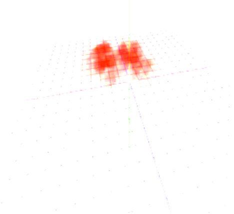


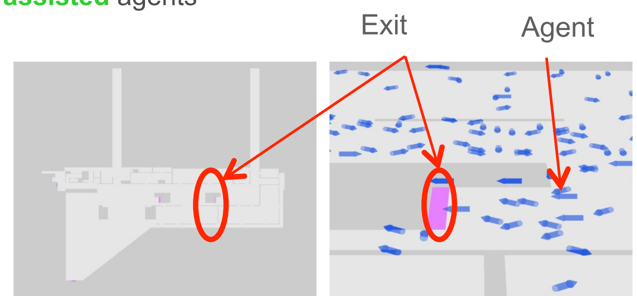
With **10% AmI-assisted** agents (purple)



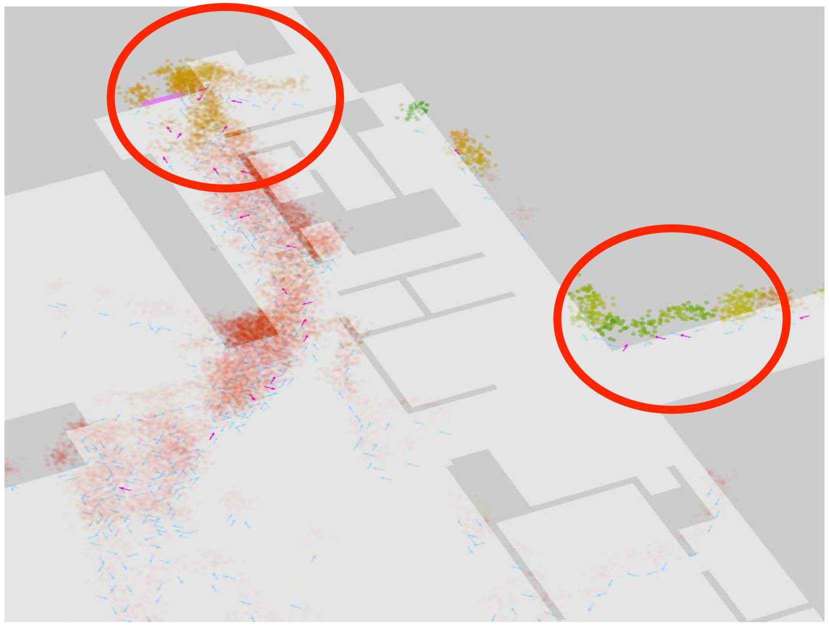
With **0% AmI-assisted** agents



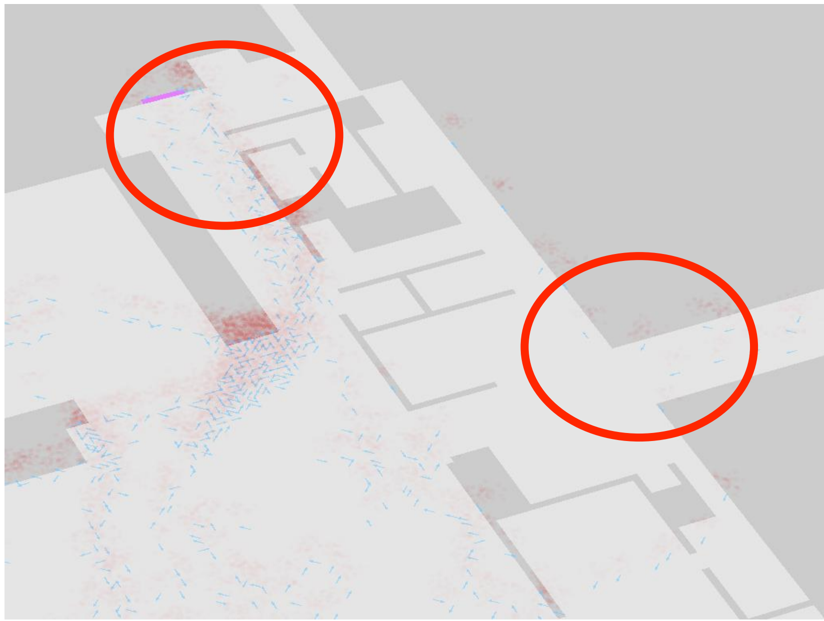




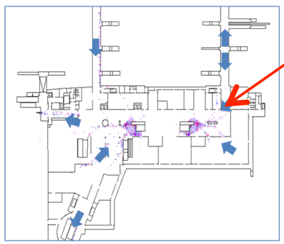
Visual Trust Analysis: Evacuating ÖBB Linz Mainstation

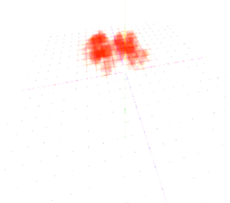


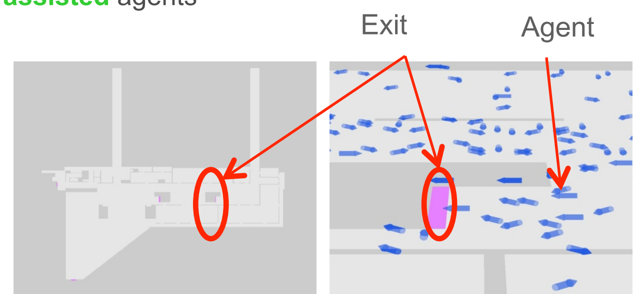
With **10% AmI-assisted** agents (purple)



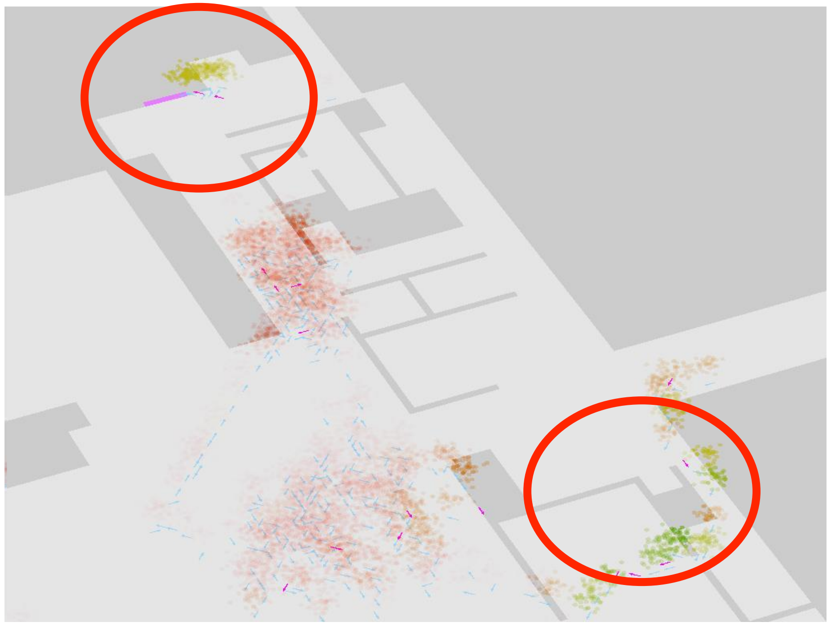
With **0% AmI-assisted** agents

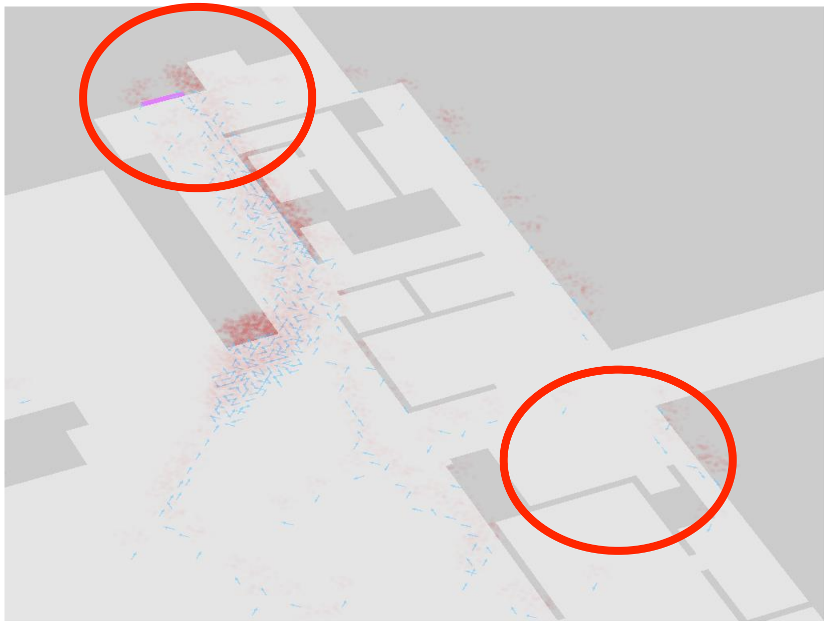






Visual Trust Analysis: Evacuating ÖBB Linz Mainstation





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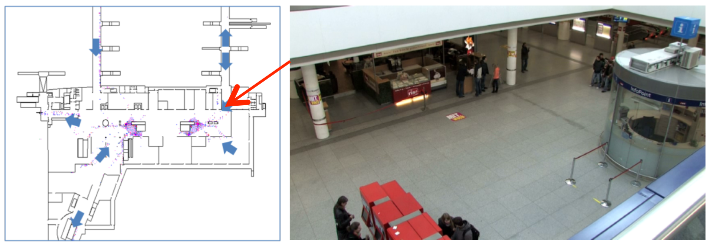
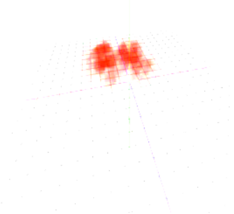
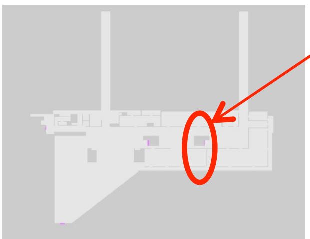
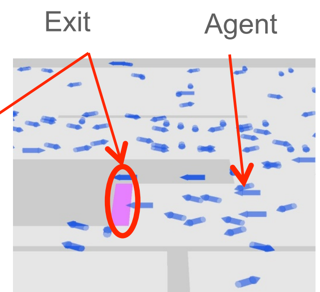
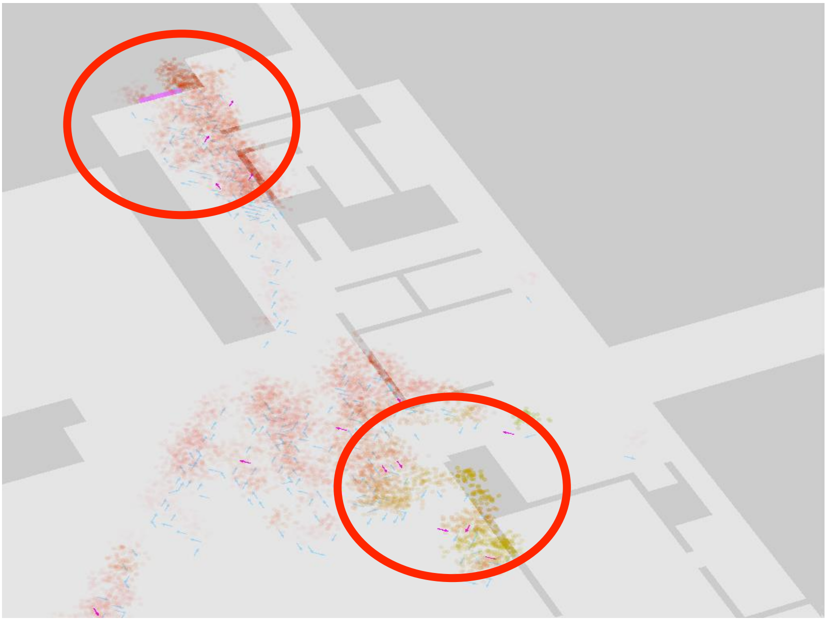


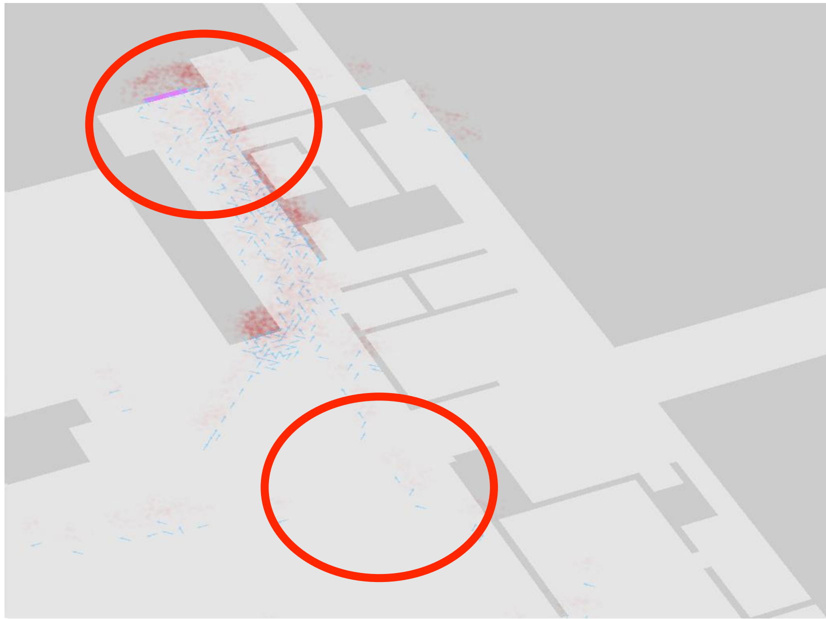






Visual Trust Analysis: Evacuating ÖBB Linz Mainstation





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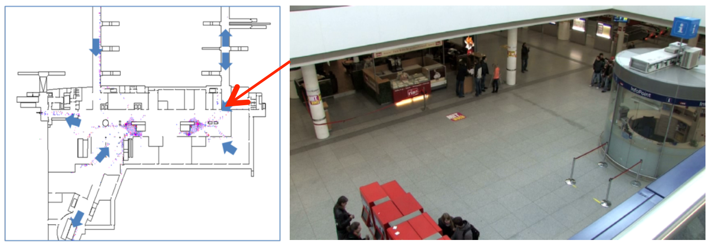
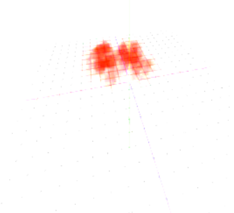
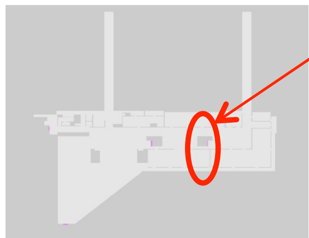
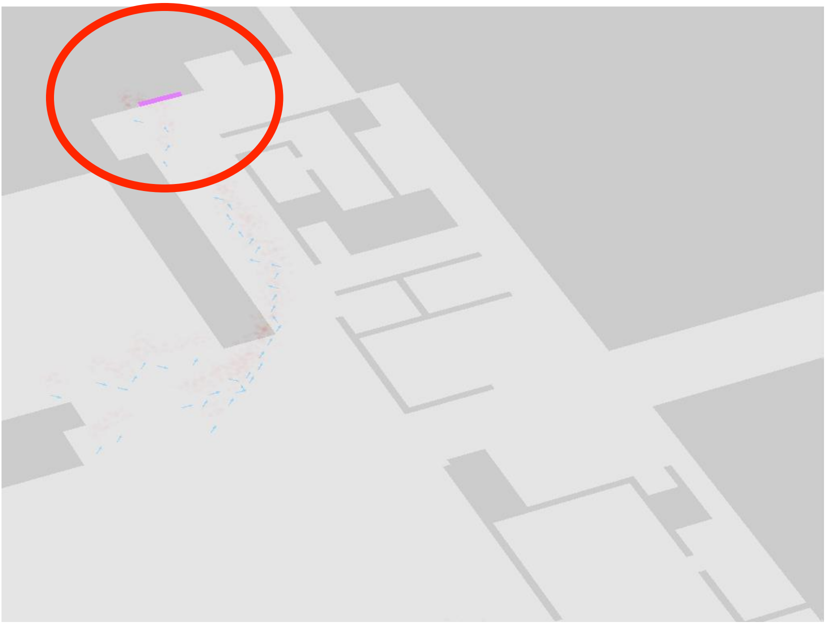






Visual Trust Analysis: Evacuating ÖBB Linz Mainstation



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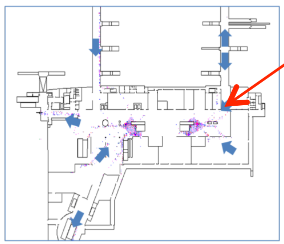
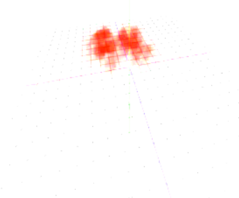
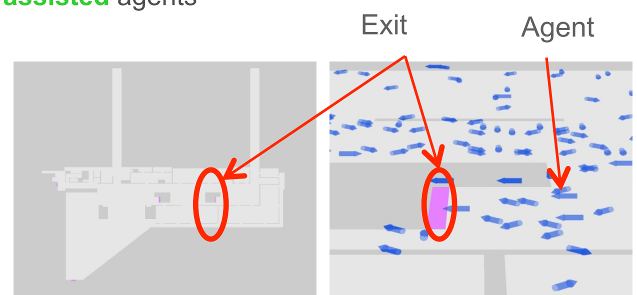






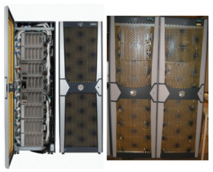
Alois Ferscha

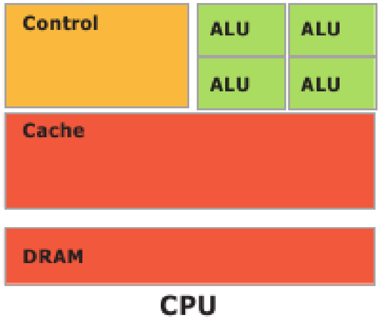
High Performance Multi (Cognitive) Agent Systems Simulation

Hardware

Shared-Memory Multi-Processor (SMP)

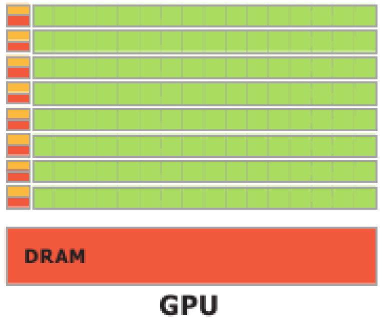
- Altix 4700 (Sgi) - 64 Blades
- 128 Intel Itanium2 Montecito CPU's (1.6GHz, 18MB L3, Dual Core)
- 1 TerraByte RAM (16GB each Blade)
- 24 x 300GB SAS hard drive
- Network (2 x 1GigaBit ,10GigaBit)





Fine Grained Parallel Processor (GPU)

- NVidia GeForce 9700M GT
- G96 PU (625MHz)
- 32 Streamprocessors
- 512MB GDDR3 (800MHz, 256Bit Bus)
- DirectX 10, Shader 4.0
- Transistors 504mill, Technology 65 nm



Software Platforms

CILK

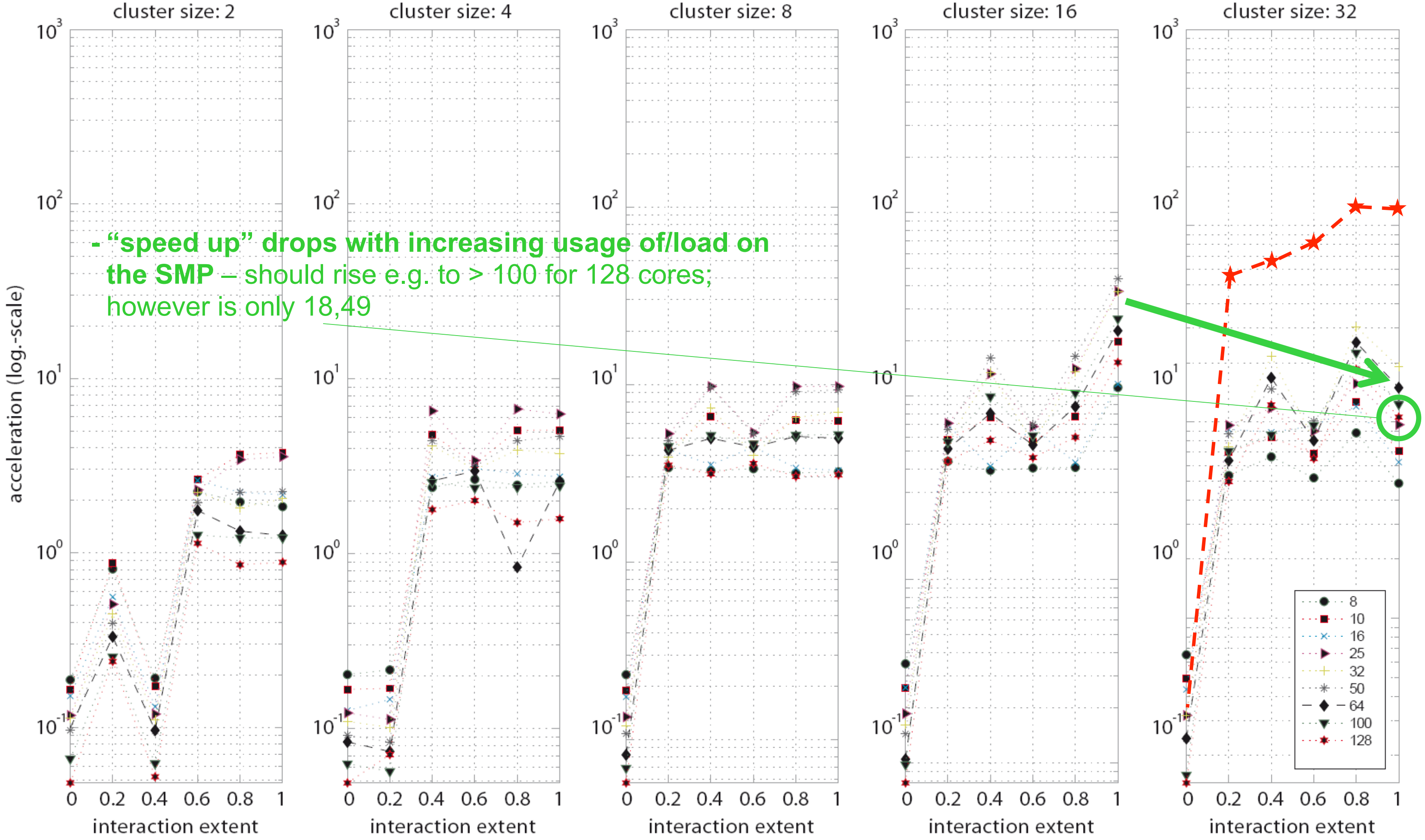
- framework to run multi-threaded programs on shared-memory machines.
- C/C++ extension
- Integrated scheduler capable to distribute the workload
- CILK was designed by the MIT (1994) and is maintained by INTEL

OpenCL

- Design: Apple Inc. and maintained by the Khronos Grp. (Apple, Intel, AMD, Google, Mozilla,…)
- Standardized Language extension for C/ C++ used with CPU's and GPU's
- To develop generalized parallel executable programs

Multi (Cognitive) Agent Systems: SMP (CILK) HPSimulation

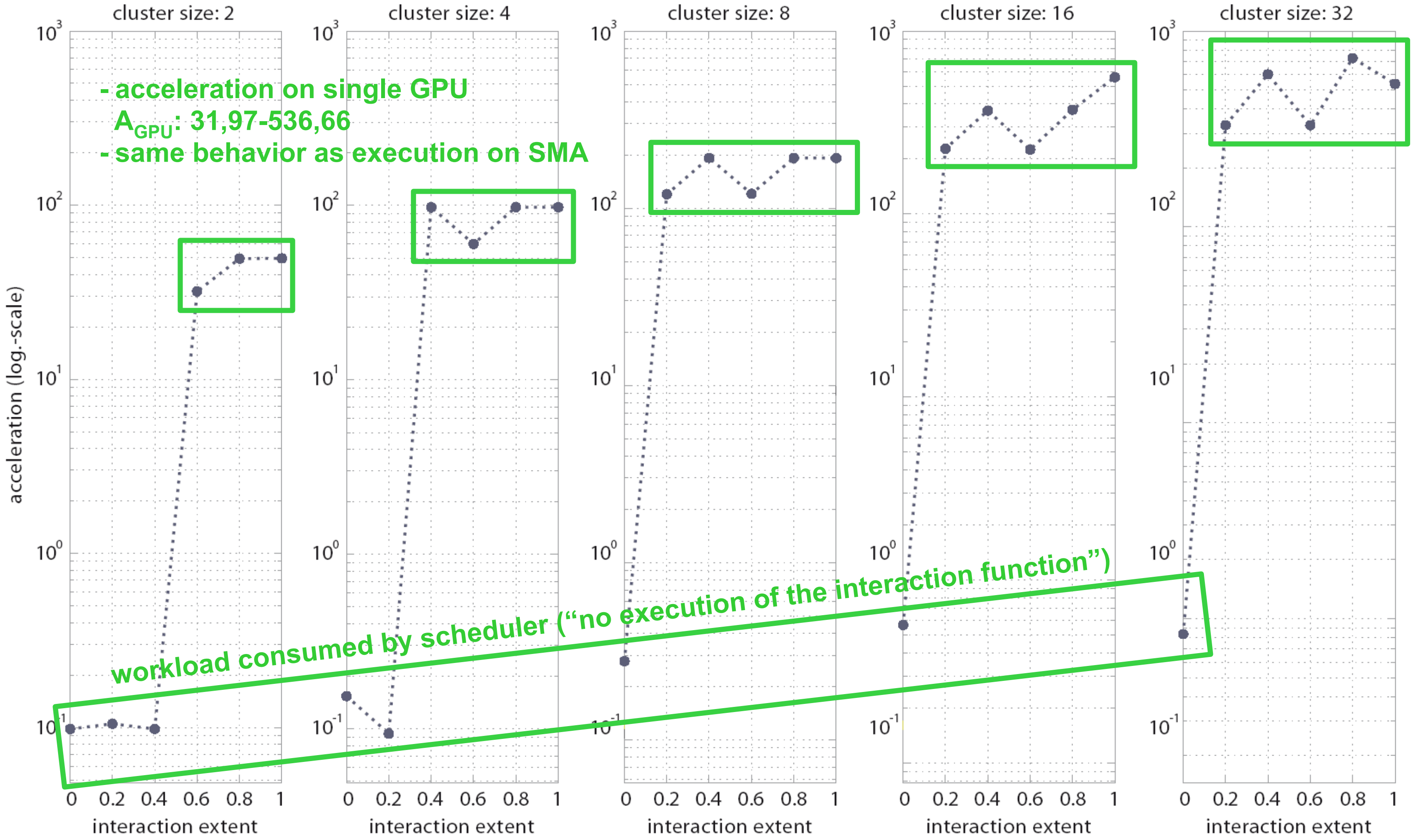
A) Trust Cluster Behavior Model (Hypothetic Floor Field, 10^7 agents)



- **"speed up" drops with increasing usage of/load on the SMP** – should rise e.g. to > 100 for 128 cores; however is only 18,49

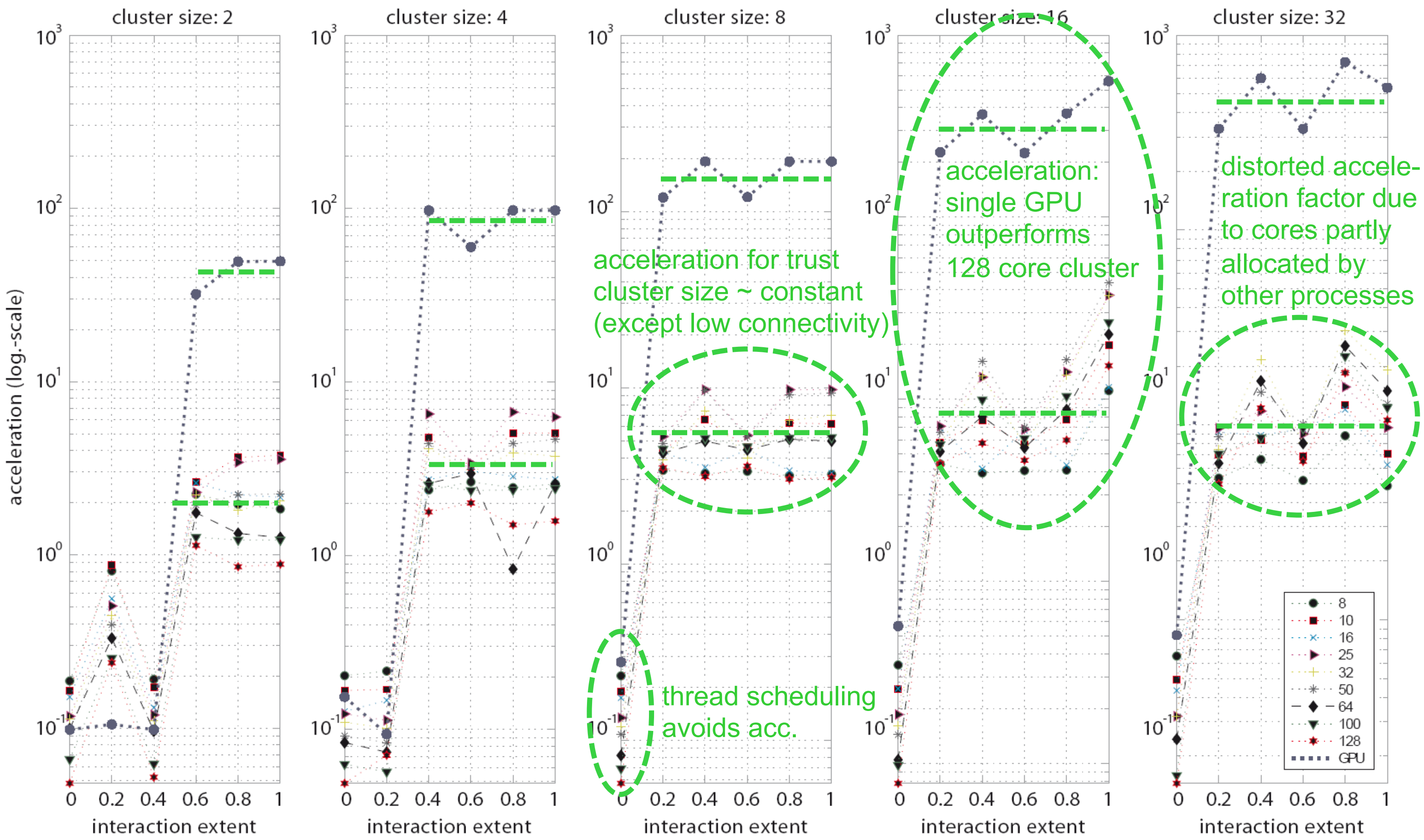
Multi (Cognitive) Agent Systems: GPU (OpenCL) HPSimulation

A) Trust Cluster Behavior Model (hypothetic floor field, 10^7 agents)



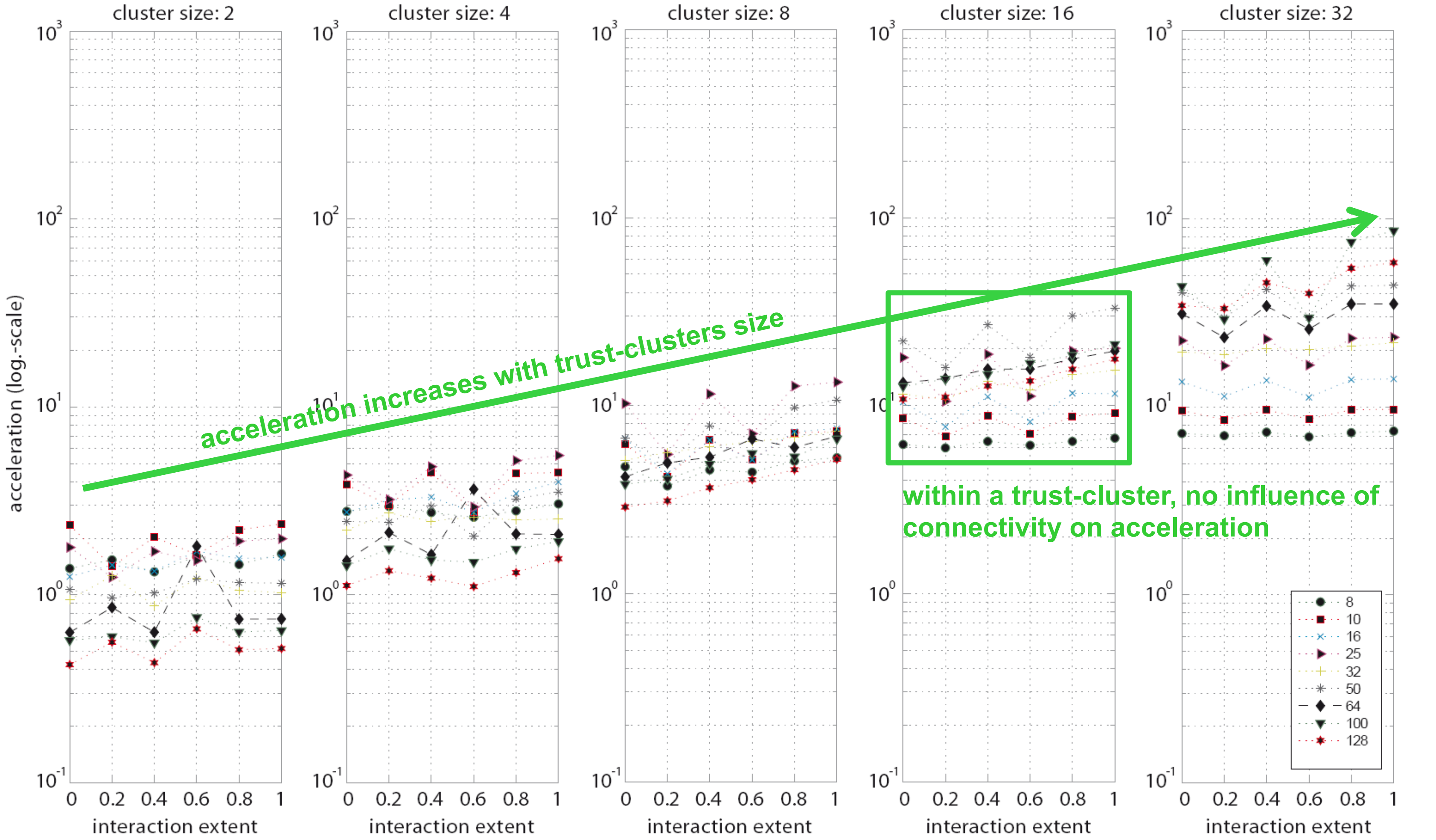
Multi (Cognitive) Agent Systems: SMP/GPU HPSimulation

A) Trust Cluster Behavior Model (hypothetic floor field, 10^7 agents)



Multi (Cognitive) Agent Systems: SMP (CILK) HPSimulation

B) Individual Behavior Model ("Realistic" Movement, Adaptation, 10^7 Agents)



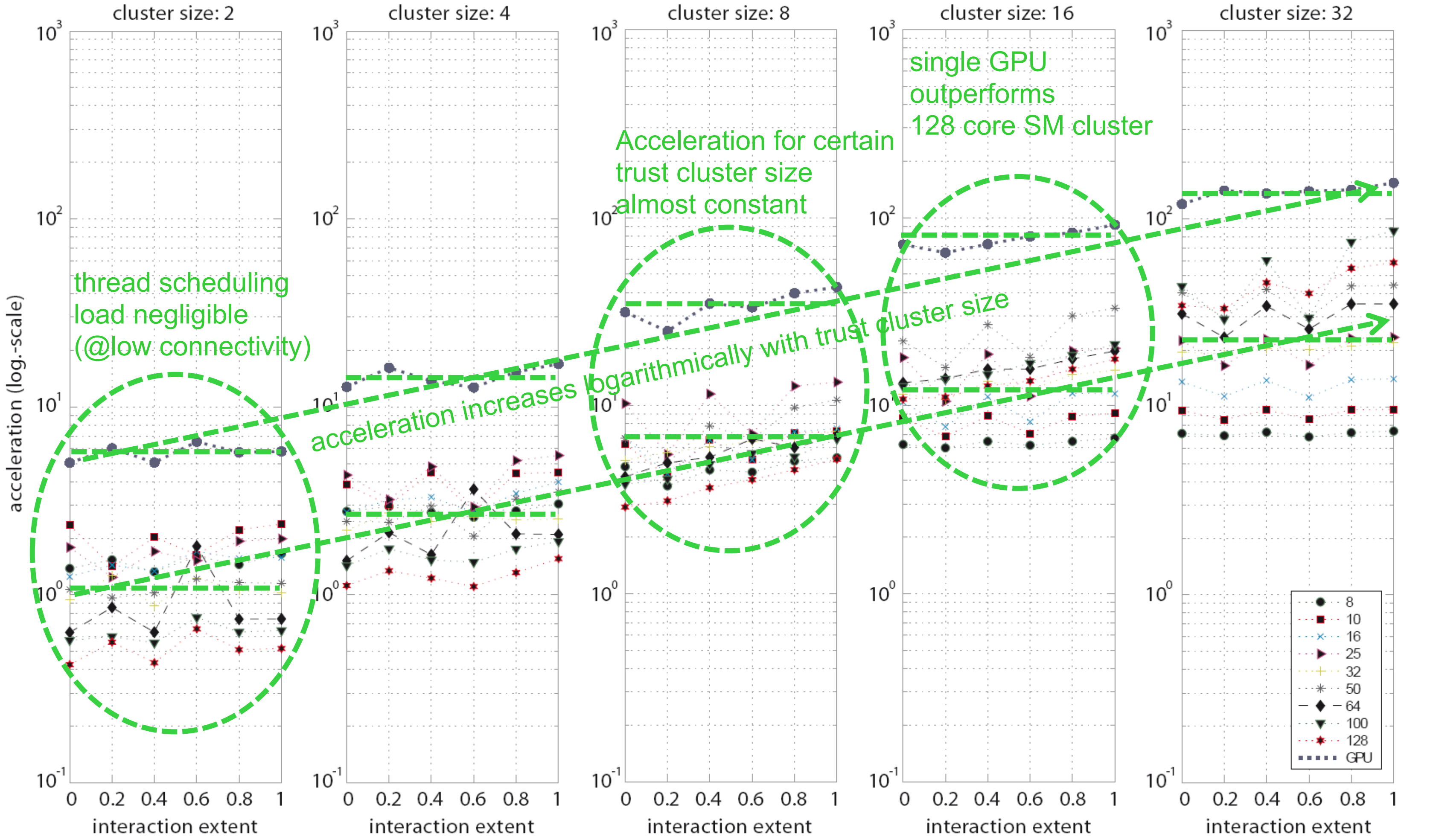
Multi (Cognitive) Agent Systems: GPU (OpenCL) HPSimulation

B) Individual Behavior Model ("Realistic" Movement, Adaptation, 10^7 Agents)

- **acceleration on single GPU**
  A_{GPU}: 5,05-155,48
- **same behavior as execution on SMA**
  (i) increasing acceleration with cluster size
  (ii) constant acceleration within a cluster (independent of connectivity)

Multi (Cognitive) Agent Systems: SMP/GPU HPSimulation

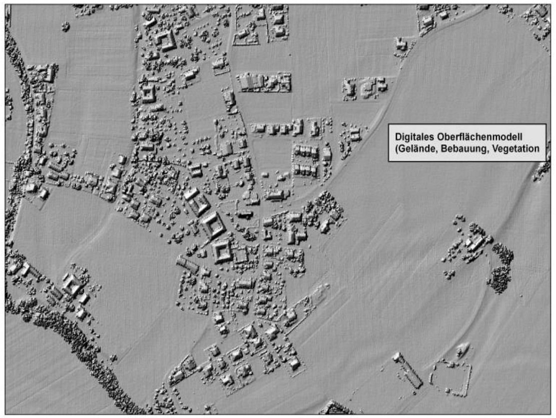
B) Individual Behavior Model (“Realistic” Movement, Adaptation, 10^7 Agents)

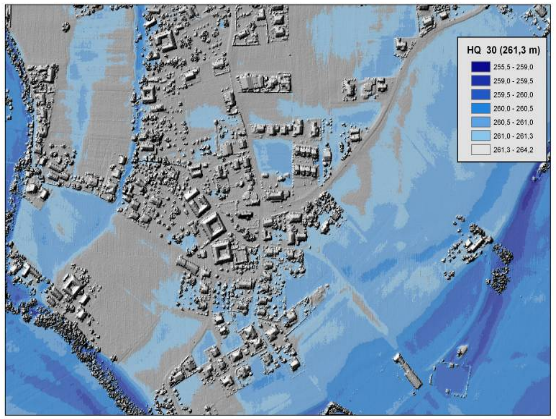


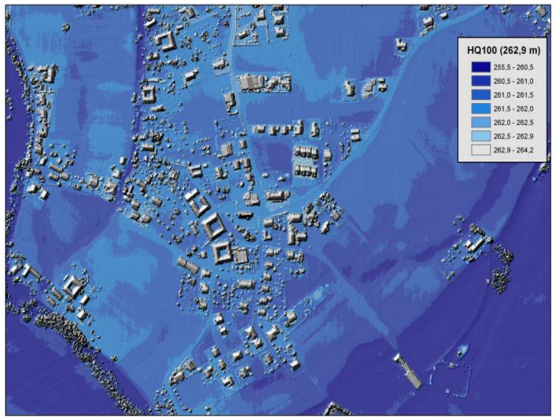
Next Steps: City Scale Evacuations

City Scale Flood Evacuation

- A comparatively mild and long term emergency situation due to large scale affect and extended timing
  - Modes: 1) Evacuating a building, 2) evacuating a city (transport), Interfacing between modes
  - Environment Modalities: unlimited (rainy, road blockages, fires etc.)
  - Variation in Objects of interest: unlimited (humans, streets, houses, trees etc.)
  - Ever changing situations: highly dynamics
  - Change of agents role
  - Extended timing: may extend across weeks
  - Models Integration across the modes
  - Simulation Tools: cannot be specific anymore







Flood in Linz 2022 (DORIS Upper Austria)

Next Steps: City Scale Evacuations

Approach: A Typology of Cities

T01 Historic Cities (e.g. Rome, London, Vienna)

T04 Gateways (e.g. Tokyo, Singapore, Dubai)

T06 Events Cities (e.g. Barcelona, Vancouver)

Classification Categories

- Governance: political systems, ethnology, economics, trade and markets, investment performance, ..
- Logistics and Infrastructure: transportation-, energy-, water-, waste-, traffic-, mobility-, telecom-networks, ..
- Topology/Scale/Geometry: urban agglomeration, megacity, ring, ring-radial, urban fringe, ..
- Demographics/Morphology: population density distribution, mobility patterns, ..
- Further Categories: Cultural Heritage, Quality of Life (Mercer) ..

Knowledge of emergencies → **Instance of a City**

AMBS (PDS)

Emergence
Evolutionary Dynamics

Typo. Features

Real Data (mobile phone)
Population Patterns

Models

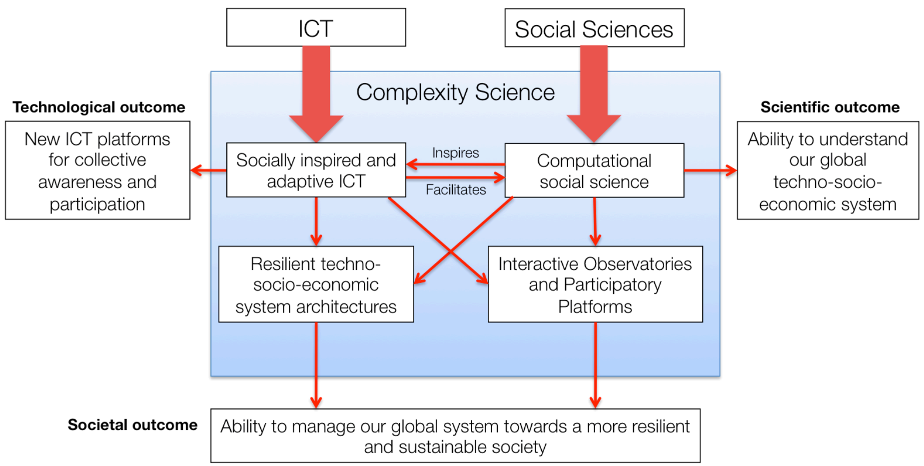
FuturICT: An opportunity for Austria

FuturICT: Future ICT Systems are Artificial Social Systems

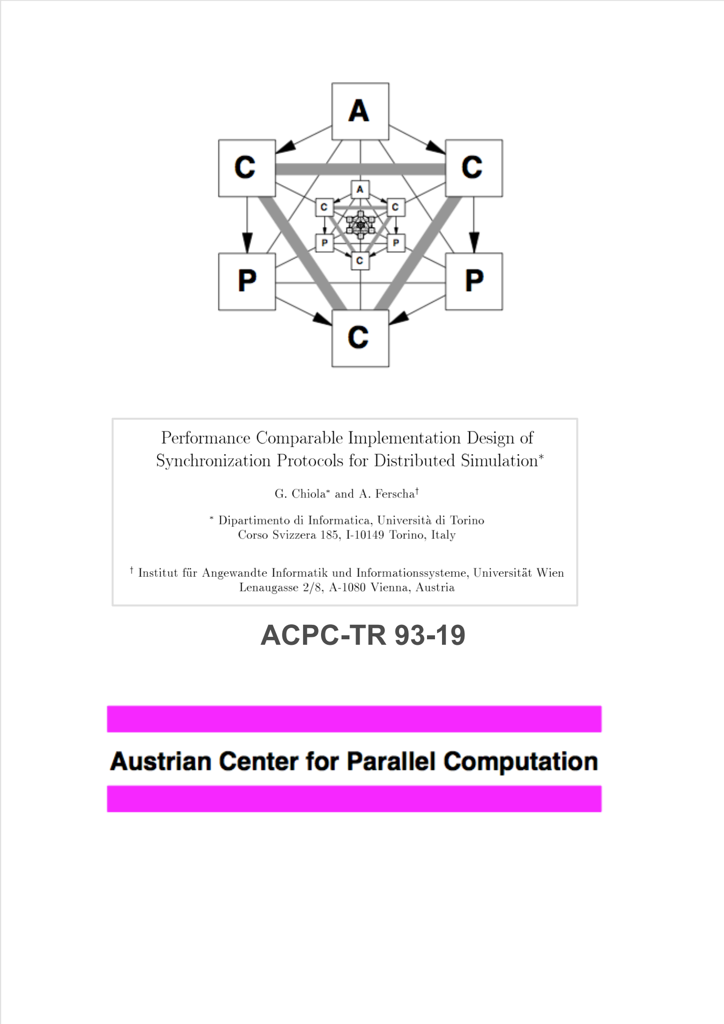
- ICT systems are made up of **billions of non-linearly interacting components** (computers, smartphones, software agents, “things”, …).
- More and more of them take **autonomous decisions**, **based on an internal representation (“subjective” interpretation)** of the surrounding world and expectations regarding future conditions.
- Most ICT systems **are not designed and tested for** the collective behavior of their components.
- A lack of coordination, instabilities, an inefficient use of resources, conflicts of interest, cybercrime and cyberwar are the result.

Selected Research Issues

- Interrelationship between structure, dynamics and function
- Strongly coupled systems, interdependent networks
- Contagion and cascading effects
- Ecological and social systems thinking
- Managing complexity
- Integrative systems design
- Resilience and systemic risks
- Sustainability
- Trust



Background



Performance Comparable Implementation Design of Synchronization Protocols for Distributed Simulation*

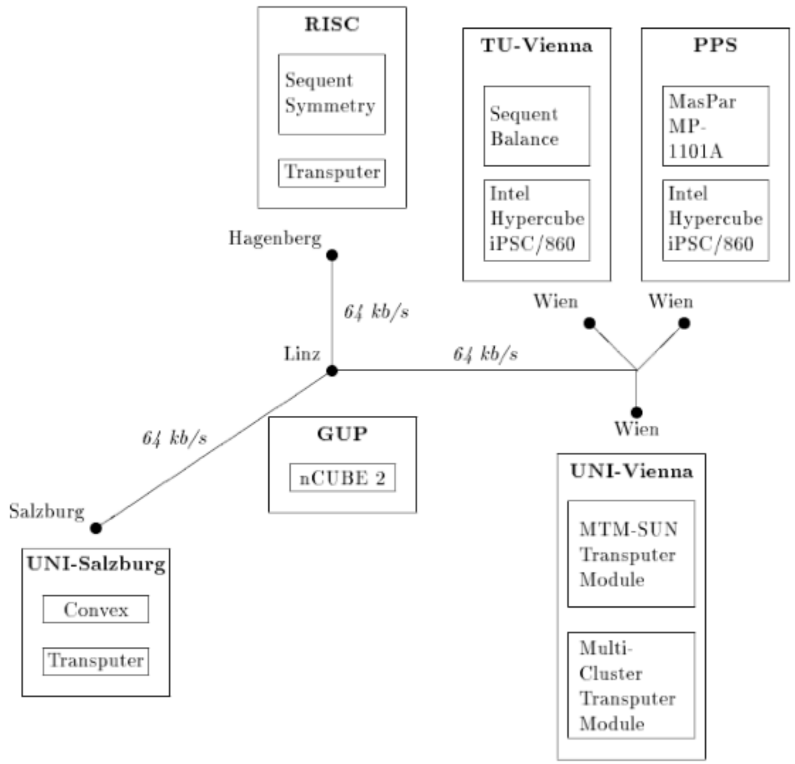
G. Chiola* and A. Ferscha†

* Dipartimento di Informatica, Università di Torino
Corso Svizzera 185, I-10149 Torino, Italy

† Institut für Angewandte Informatik und Informationssysteme, Universität Wien
Lenaugasse 2/8, A-1080 Vienna, Austria

ACPC-TR 93-19

Austrian Center for Parallel Computation



The „ACPC-Map“, May 14, 1993

What is ACPC?

Chapter 1

Introduction

1.1 What is the ACPC?

The Austrian Center for Parallel Computation (ACPC) is a joint organization formed by seven institutes at the universities of Linz, Salzburg and Vienna. The ACPC was founded in 1989 to promote research, education and industrial cooperation in the area of parallel computation in Austria and is supported by the Austrian Research Foundation and the Austrian Ministry of Science and Research. At present, approximately 50 researchers at the levels of professor, senior and junior researcher, and doctoral student from these seven groups are united in the ACPC effort.

Each group of the ACPC is specialized in a different subarea of parallel computation (parallel symbolic computation, parallel numerical applications, parallelization of programming languages, parallel computer graphics and visualization, theory of parallel computation, parallel hardware and software systems, ...). Hence, the ACPC groups profit from a lot of synergy effects by several joint research projects.

My Deepest Respect … (1989)





Participants in the ACPC are at present seven academic groups headed by (in alphabetical order):

Prof. Bruno Buchberger, RISC-Linz

Prof. Günter Haring, Institute for Applied Computer Science and Information Systems, University of Vienna

Dr. Wolfgang Kleinert/Doz. Christoph Überhuber, Technical University of Vienna

Prof. Peter Schuster/Doz. Othmar Steinhauser, Theoretical Chemistry Group, University of Vienna

Prof. Jens Volkert (Spokesman), Department for Computer Graphics and Parallel Processing, Institute for Computer Science, University of Linz

Prof. Hans P. Zima, Institute for Software Technology and Parallel Systems, University of Vienna

Prof. Peter Zinterhof, RIST++ Salzburg

SOCIONICAL JKU Research Team

Acknowledgement

SOCIONICAL

Complexity Science based modelling, prediction and simulation methods for large scale Socio-technical systems; an **FP7 Project**

VU University Amsterdam, Agent Systems Research Group