universität freiburg

Theses and Projects at CoNe

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Technische Fakultät
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IIF INSTITUT FÜR INFORMATIK FREIBURG

CoNe Freiburg

Projects and Theses

General Remarks

Your Project

Localization

Computational Complexity

Peer-to-Peer Networks

Telocate

MIMO and Near-Field

Visual Cryptography

Cryptography

General Remarks

What, where, how?

Our Group
Who, what, where?

- **People**
  - Prof. Dr. Christian Schindelhauer
  - Sneha Mohanty
  - Saptadi Nugroho
  - Peter Krämer
  - Dr. Joan Bordoy (Telocate)
  - Dr. Johannes Wendeberg (Telocate)
  - Dr. Fabian Höflinger (Telocate)
- **Partners**
  - Telocate
  - Prof. Dr. Stefan Rupitsch






General Remarks

What is a project?
What is a thesis?

- **Study programs at the Faculty**
  - Computer Science, Embedded Systems Engineering, (IMTEK, SSE)
  - Bachelor, Master, (PhD, PostDoc)
- **Project**
  - Bachelor project (6 ECTS)
  - Master project (18 ECTS)
- **Theses**
  - Bachelor Thesis (15 ECTS)
  - Master Thesis (30 ECTS)

- **Projects**
  - are practical and should train for your future work as an engineer/IT specialist
  - help us to perform research
  - can be the warm-up phase for a thesis
- **Theses**
  - is the plural of thesis
  - is an academic individual work of the student
    - i.e. could lead to a scientific publication

Types
What kinds of projects/theses exist?

Theory

- Mathematical treatment of a topic
  - i.e. Theorem, Lemma, Proof

Practical Work

- Design, Implementation, Set-up, Testing
- of programs or embedded systems

Experimental Work

- Design of an experimental buildup
- Documentation of the setup, experiments and surrounding
- Analysis of the experiment and conclusion
  - may involve programming, building a system, etc.

Lemma 7. *The expected potential in round $t+1$ is at most $\left(r^2+(1-r)^2\left(1-\frac{1}{n}\right)\right)$ times the potential in round t. Formally: $\mathbb{E}\left[\Phi_{t+1}|\Phi_t=\phi\right] \leq \left(r^2+(1-r)^2\left(1-\frac{1}{n}\right)\right)\phi$.*

Proof. The proof is similar to the proof in [5]. The key difference is the parameter r. For ease of notation, the time indices are dropped. Given all $v_{i,j}$ and all calling assignments $f(i)=k$ at time t the potential in the next round can be computed as:

$$\Phi_{t+1} = \sum_{i,j}\left(rv_{i,j} + \sum_{k:f(k)=i}(1-r)\,v_{k,j} - \frac{rw_i + \sum_{k:f(k)=i}(1-r)\,w_k}{n}\right)^2 \tag{17}$$

$$= \sum_{i,j}\left(\underbrace{r\left(v_{i,j}-\frac{w_i}{n}\right)}_{a} + \underbrace{\sum_{k:f(k)=i}(1-r)\left(v_{k,j}-\frac{w_k}{n}\right)}_{b}\right]^2 \tag{18}$$

$$= \underbrace{\sum_{i,j} r^2\left(v_{i,j}-\frac{w_i}{n}\right)^2}_{a^2} + \underbrace{\sum_{i,j} 2r\left(v_{i,j}-\frac{w_i}{n}\right)\sum_{k:f(k)=i}(1-r)\left(v_{k,j}-\frac{w_k}{n}\right)}_{2ab} \tag{19}$$

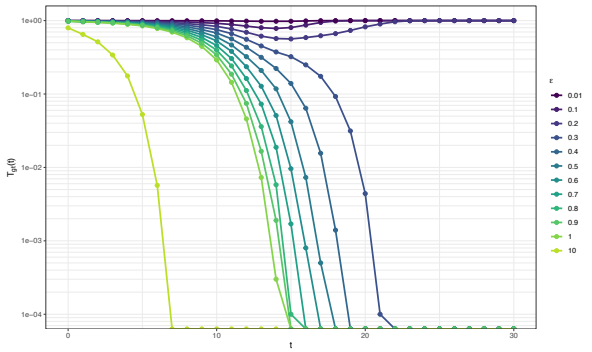


Figure 15: Tail weight $T_{gt}(t)$ of 10000 nodes aggregating the average using *Random-Call-Pull*. The inputs to the nodes are constant and uniformly distributed from the interval $[0, 100]$.

Design and Implementation of a Simulation Environment for Peer-to-Peer based Data Aggregation of Time-Series Data
Alexander Weinmann June 29, 2021

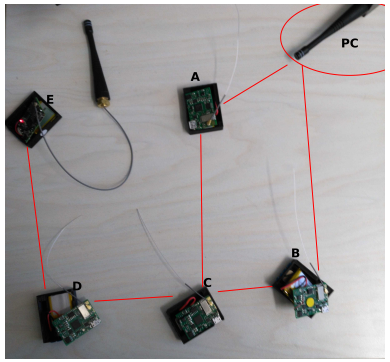


Figure 13: Experiment with ignore lists for each node

GasLok Network Protocol
Philip Klein 2020

Timeline of a Project/Thesis

Preparing

- contact the contact person
- work out the specifics of the task
- get the literature
- get the material

Starting

- register with the examination office
- kickoff presentation at the Oberseminar
  - contact Sneha Mohanty

Working

- go to meetings
  - especially if you think there is nothing to report
- stay in contact with your contact person
- report difficulties, new insights, successes

Finishing

- **deadlines of theses are strict**
  - except you break your arm or leg
  - then apply for an extension at the examination office
- projects have no fixed deadline
- submit your thesis to the examination office
- or submit your project report to your contact and to the chair (me)
- make a final presentation

Your Project

Everything you have ever dreamt of

Many Industrial Projects and Theses are Scams

- Famous, prestigious companies are **scamming students**
- **Promise thesis**
  - *„tHe OnLy tHiNg yOu nEeD iS tO fInD a sUpErVisiNg pRoFeSSor“*
  - offer some money
- **BUT**
  - finding a supervisor is **their job**
  - offered theses are often **not academic**
  - offered money is way below your pay grade
  - They want hard work for cheap money

- **If you find a supervisor and start such a thesis**
  - **Plus**
    - Money and a thesis
    - contact to company
  - **Minuses**
    - you have two bosses
    - you cannot publish your results NDA
    - worse grades, less money
    - finding a job is not a problem
    - you are wasting your only chance to get into academic research

The good industrial theses and Pitch your idea.

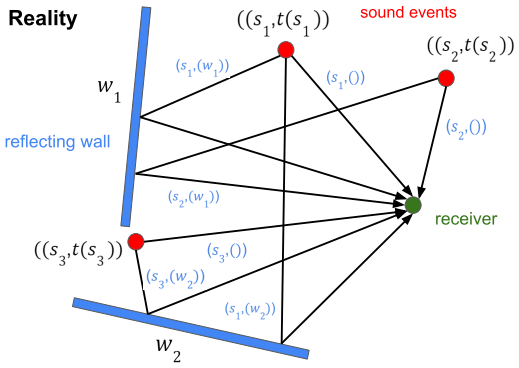
- The **good** industrial theses
  - the supervisor is in the field, e.g. computer scientist
  - supervisor has a publication record
  - contacts to universities have been established
  - they are interested in publishing the results
- **Good industrial projects**
  - projects work much better than theses with industry
  - but, they do not know how grading works…
- **or just going YOUR WAY**
- **You have an original idea**
  - tell us about it
  - show us that it has academic potential
  - show us the relation to our research
    - or at least the name of the chair
- You work out the fine print
  - own literature research
  - own risk
  - but also your own chance of doing your thing

Localization

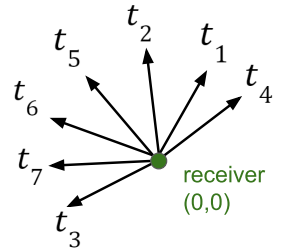
ILDARS, Self-Calibration
Signal Processing

ILDARS

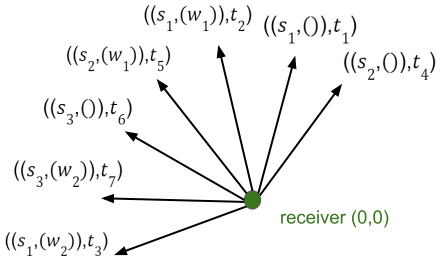
- A silent bat hears some other bats
  - can detect the direction and the time of a sound signal
  - can be directed or reflected signal
- Question:
  - What can a silent bat locate?
  - ILDARS problem (Indoor Localization problem based on Directed and Reflected Signals)
- Oracle version:
  - The names of the reflecting walls are given
    - e.g. in a characteristic table
- Literature
  - Mohanty, S., What can a Silent Bat Locate?, draft, 2023



ILDARS Problem



Oracle ILDARS problem



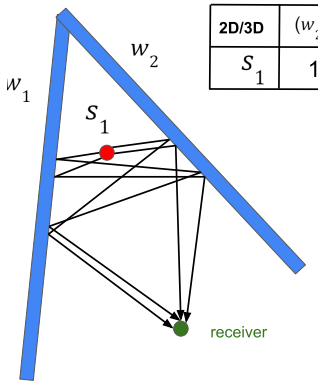
Characteristic Table

Line of sight

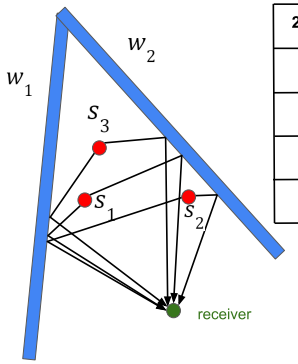
2D	()	(w_1)	(w_2)
s_1	(d_1,t_1)	(d_2,t_2)	(d_3,t_3)
s_2	(d_4,t_4)	(d_5,t_5)	$\emptyset$
s_3	(d_6,t_6)	$\emptyset$	(d_7,t_7)

Oracle-ILDARS

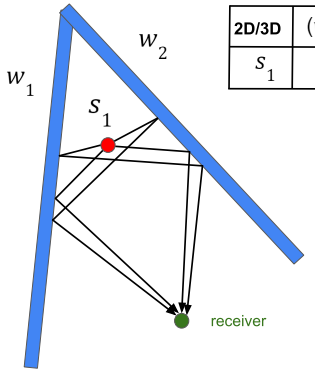
- Task:
  - Which cases or Oracle ILDARS are solvable?
- Literature
  - Mohanty, S., What can a Silent Bat Locate?, draft, 2023
- Contact
  - Christian Schindelhauer, Sneha Mohanty



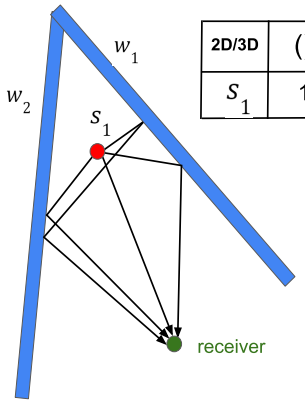
2D/3D	(w_2)	(w_1,w_2)	(w_2,w_1)	(w_1,w_2,w_1)
s_1	1	1	1	1



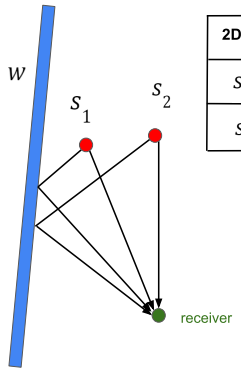
2D/3D	(w_1)	(w_2)
s_1	1	1
s_2	1	1
⋮	⋮	⋮
s_n	1	1



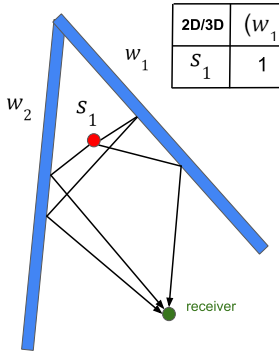
2D/3D	(w_1)	(w_2)	(w_1,w_2)	(w_2,w_1)
s_1	1	1	1	1



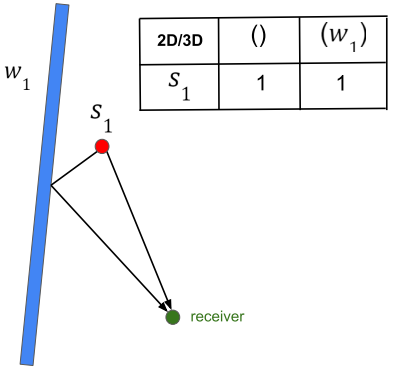
2D/3D	()	(w_1)	(w_2)	(w_1,w_2)
s_1	1	1	1	1



2D/3D	()	(w)
s_1	1	1
s_2	1	1



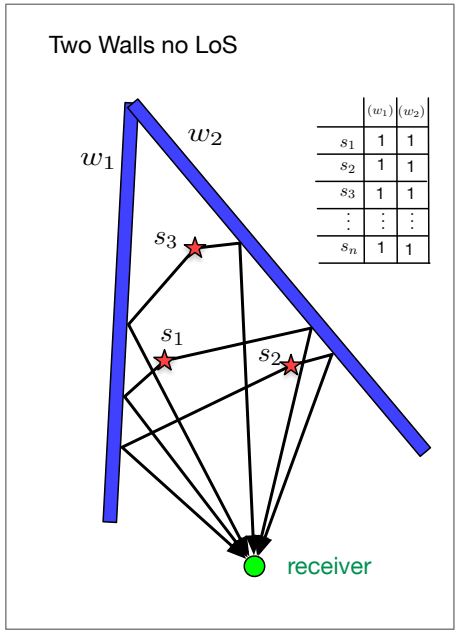
2D/3D	(w_1)	(w_2)	(w_1,w_2)
s_1	1	1	1

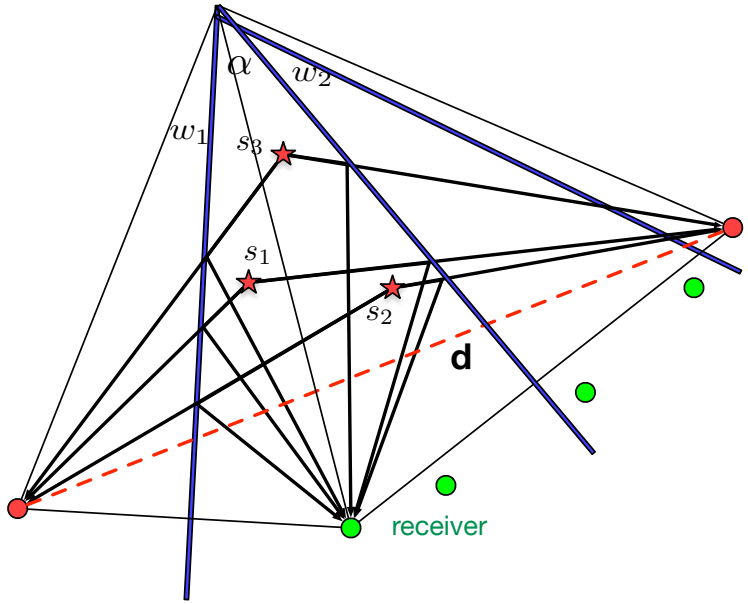


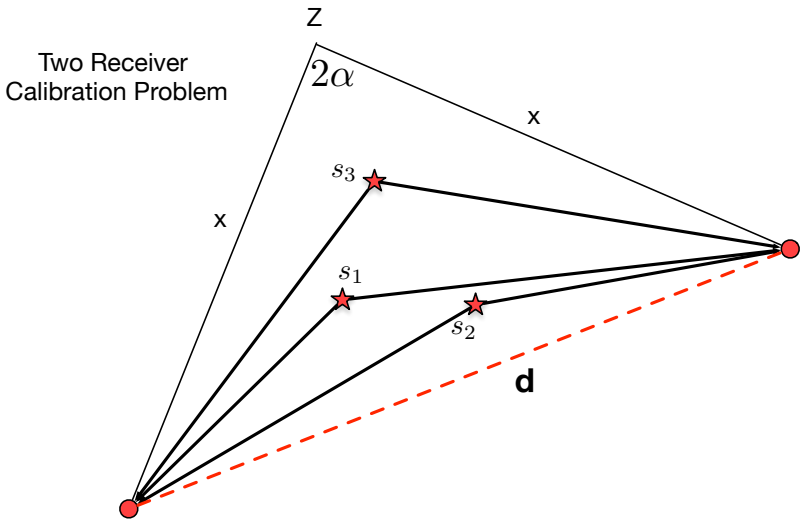
2D/3D	()	(w_1)
s_1	1	1

Two Receiver Calibration Problem

- The Two-walls-no-LOS-Oracle ILDARS is equivalent to **two receiver calibration problem**
- Question: How to calibrate two receivers using pairs of incoming signals
  - Given the direction and the time of arrivals at two receivers with unknown distances and orientation
  - In which direction is the other receiver and in which distance?
- **Task**:
  - Test optimization methods to solve it
  - Find a closed form solution if possible
- Contact
  - Christian Schindelhauer, Joan Bordoy







Silent Bat in Sound Architecture

- In the silent bat approach we have assumed walls in general position
- **Question**
  - Can we transfer the results to parallel and rectangular mirrors?
  - How about new shapes (planes, spheres, cylinders)
- **Task**
  - Find algorithms to detect such walls and perform localization
- Contact
  - Christian Schindelhauer
  - Sneha Mohanty

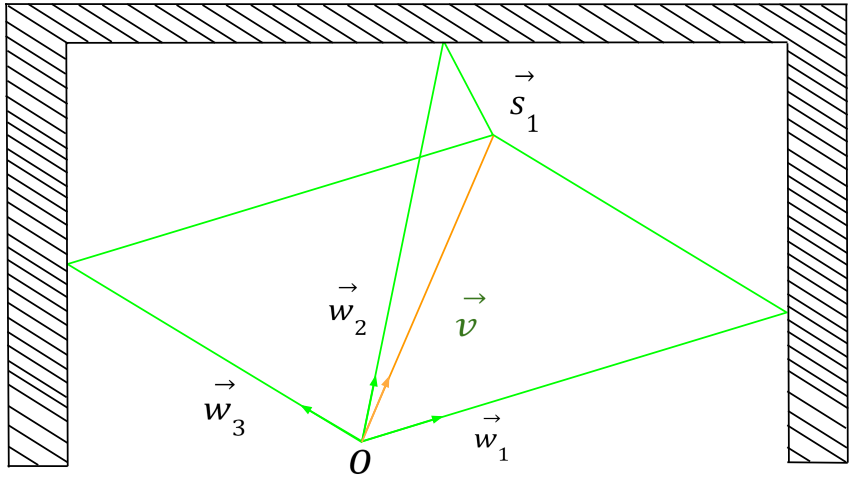


Fig. 1. Receiver device at position o receives one direct and multiple reflected signals from sound source s_1

Signal Processing for ILDARS

- Based on several incoming signals
  - predict pairing and order of reflection
  - differentiate and detect reflected and LOS signal
- Literature
  - Gabbrielli, 3-D Angle of Arrival Ultrasonic Indoor Localization System with Chirp Spread Spectrum Multi-User Identification, PhD Thesis, 2023
- Contact
  - Christian Schindelhauer, Sneha Mohanty

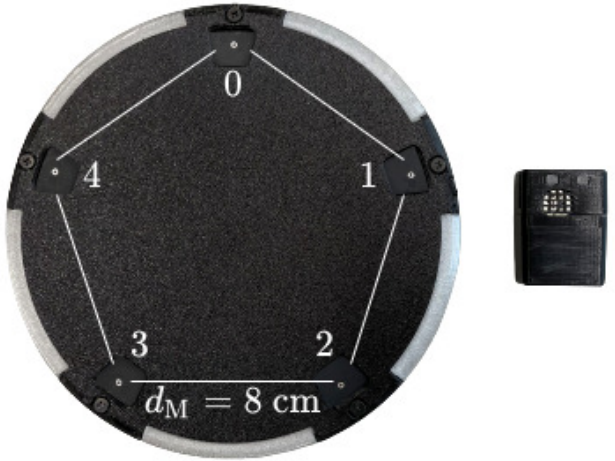
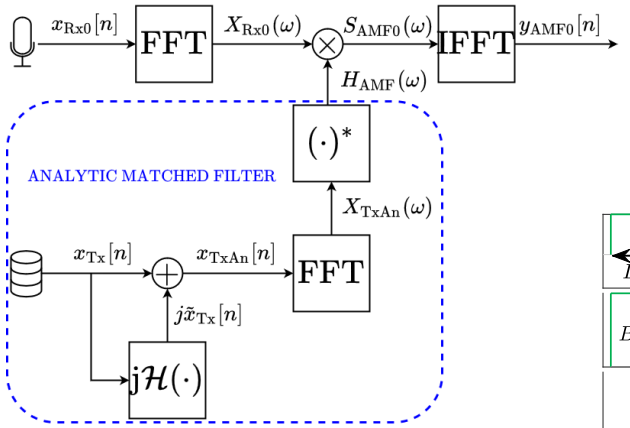


Fig. 2. The AoA ultrasonic receiver composed of 5 microphone placed on a pentagon of length $d_M = 8$ cm (on the left) and the ultrasonic speaker tag (on the right).



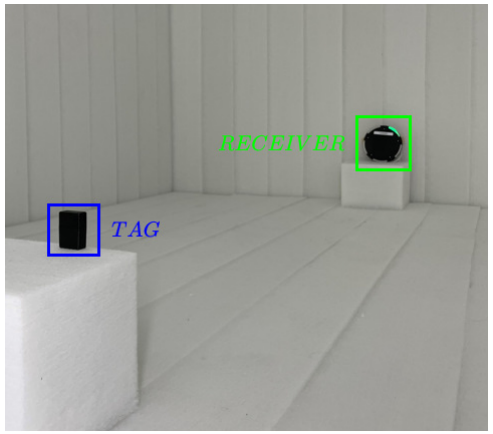


Fig. 3. Test setup in the ultrasonic anechoic chamber. The receiver and tag are place at 1 m distance, facing each other.

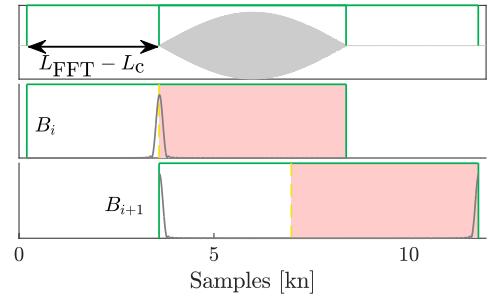


Fig. 8. Peak search limit case. *Top plot*: Both blocks entirely include the chirp stored in the ring buffer. *Middle and bottom plot*: The chirp is included in both B_i and B_{i+1}, however only the half compressed pulse is present in the peak search region.

ILDARS Simulation for Complex Scenarios

- **Task**
  - Simulations and improving of localization algorithms for
  - **Multiple Reflections** (recursive Half-Circle-Lemma
  - **Complicated Scenarios**
- **Literature**
  - Mohanty, Müller, S, Simulation of a first prototypical 3D solution for Indoor Localization based on Directed and Reflected Signals, Poster IPIN, 2023
- Contact:
  - Christian Schindelhauer, Sneha Mohanty

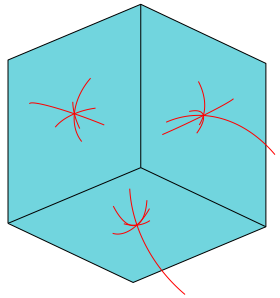


Fig. 3. Circular Segments from three different walls

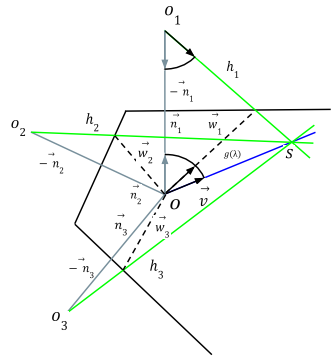


Fig. 7. Closest Lines extended

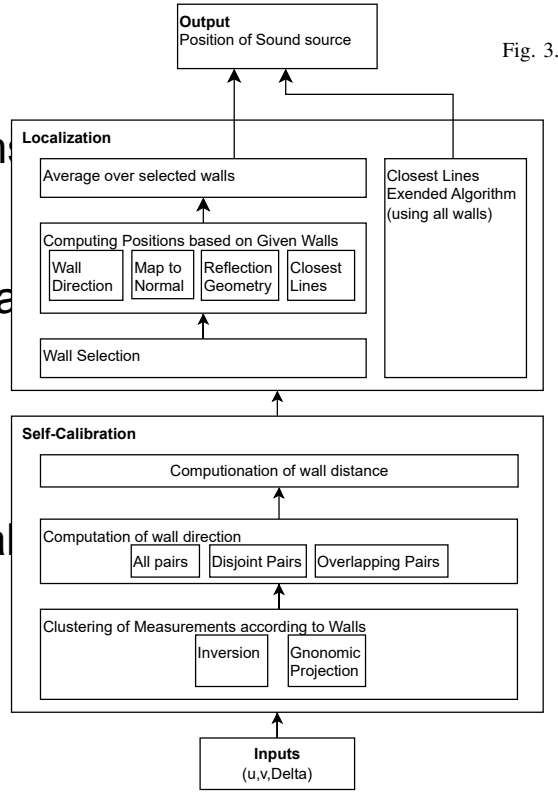
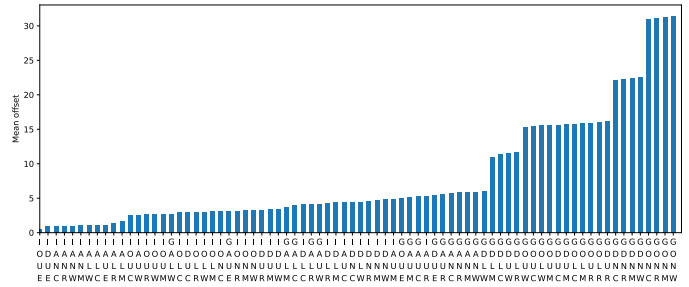
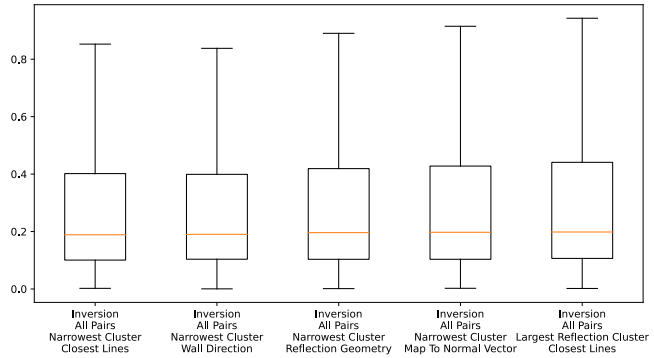


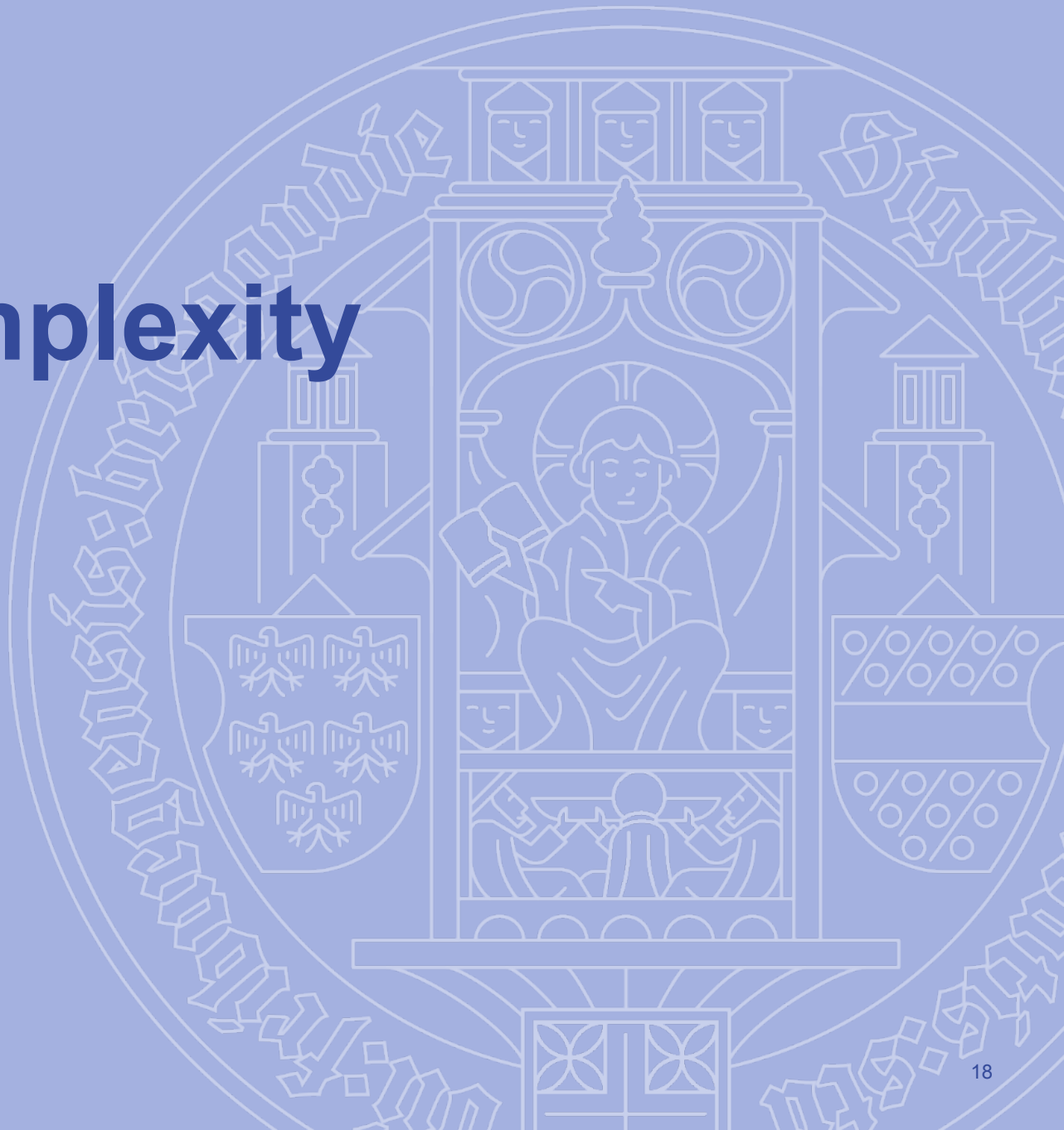
Fig. 2. Design of the ILDARS system





Computational Complexity

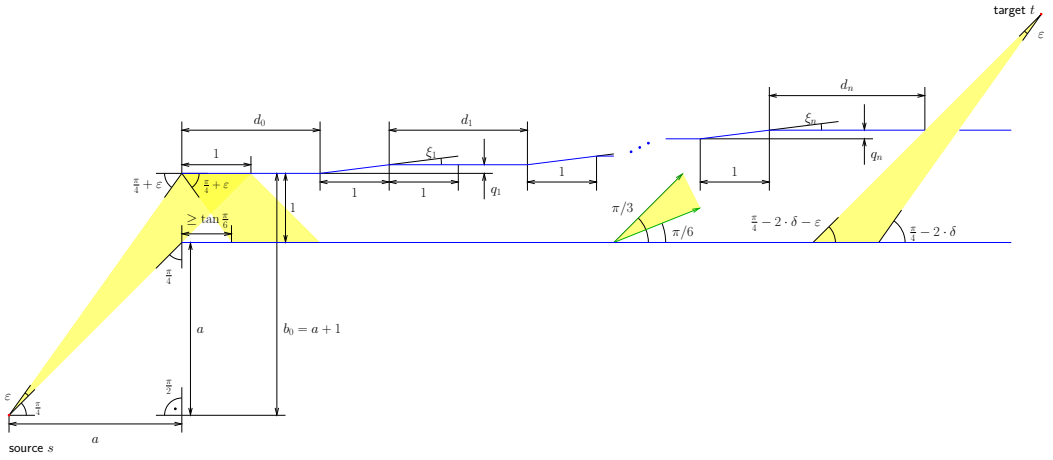
Proving the hardness



Computational Complexity of Mirrors

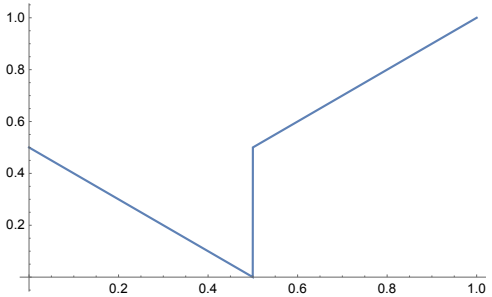
- **One result thesis**
  - **2-D RayTracing is RE hard**
- Tasks (theory)
  - Find alternative proofs for hardness
  - Loop construction
  - Complexity of **Arrival time**
- Literature
  - Adejoh, Jakoby, Mohanty, S., „Complexity Bounds for Illumination and Ray Tracing in 2D“, draft, 2023
  - John H. Reif, J. Doug Tygar, and A. Yoshida. Computability and complexity of ray tracing. Discrete & Computational Geometry, 11:265–288, 1994.

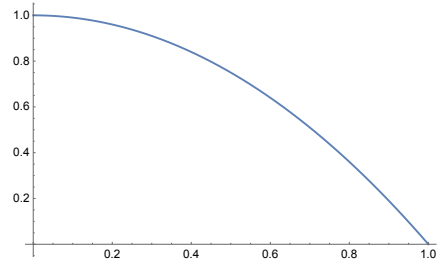
▶ **Theorem 7.** *The illumination problem restricted to simple plane mirrors in 2D is $\mathcal{NP}$-hard, if an exponential number of reflections is allowed.*

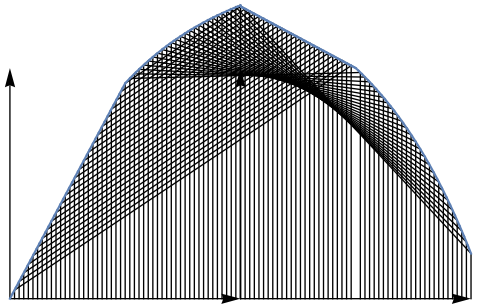


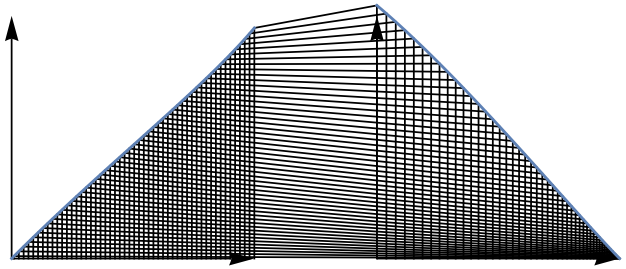
Computational Power of Mirrors

- **Mirrors are computational tools**
  - Input/output Direction, offset, time
  - What is the computational power
- **Tasks**
  - Create mirrors performing given operations
  - Prove that it is hard to compute when a signal of a point has arrived at a target
  - Design mirror system that compute complex tasks or fulfill other properties
    - e.g. an aerodynamic car mirror using multiple reflections
- Literature
  - Serge Tabachnikov. Geometry and billiards, volume 30. American Mathematical Soc., 2005.
- Contact
  - Christian Schindelhauer, Sneha Mohanty





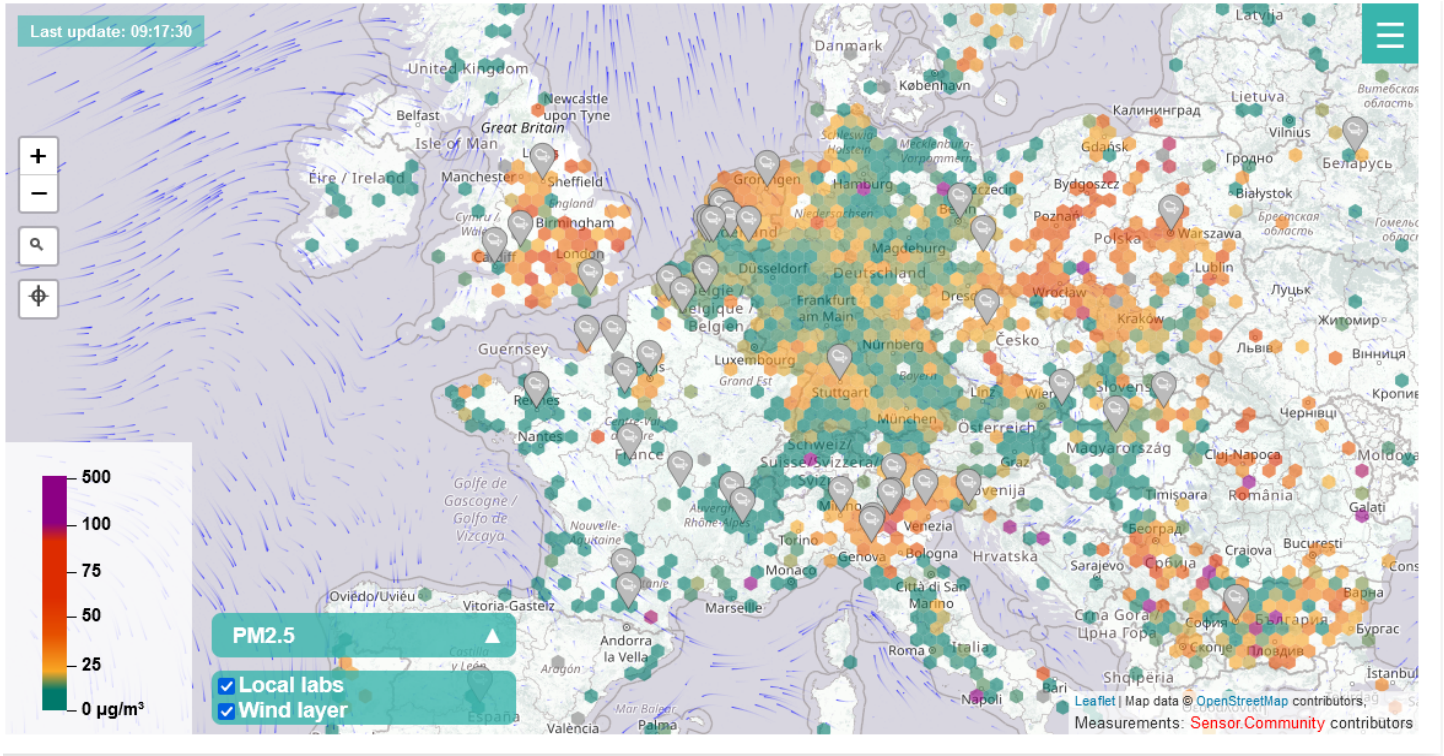




Peer-to-Peer Networks

Everybody is equal

Data Aggregation in Peer to Peer Network



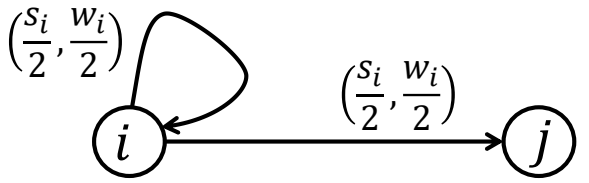
- **Given**
  - Sensors and data from sensor.community
- **To do**
  - Compute/Simulate the asynchronous rumor spreading
    - Aggregation Function (Min, Max, Average, Sum, Count)
- **LIterature**
  - Ormándi, R., Hegedűs, I., Jelasity, M. (2011). Asynchronous Peer-to-Peer Data Mining with Stochastic Gradient Descent. In: Jeannot, E., Namyst, R., Roman, J. (eds) Euro-Par 2011 Parallel Processing. Euro-Par 2011. Lecture Notes in Computer Science, vol 6852. Springer, Berlin, Heidelberg.
- **Contact**
  - Christian Schindelhauer
  - Saptadi Nugroho (saptadinugroho at gmail.com)

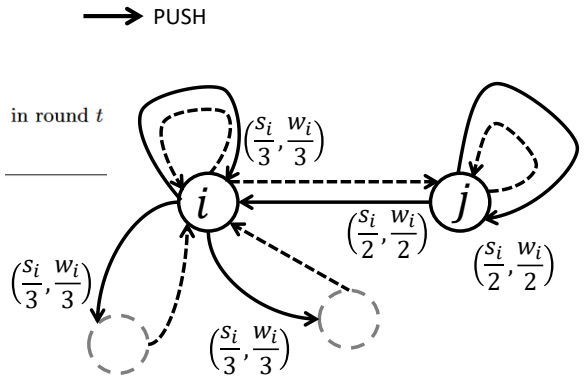
Smart sensor agents can communicate with each other in a communication network to exchange data. Each sensor agent produces measurement data. In this project we will try to simulate asynchronous data aggregation using data from sensor.community.

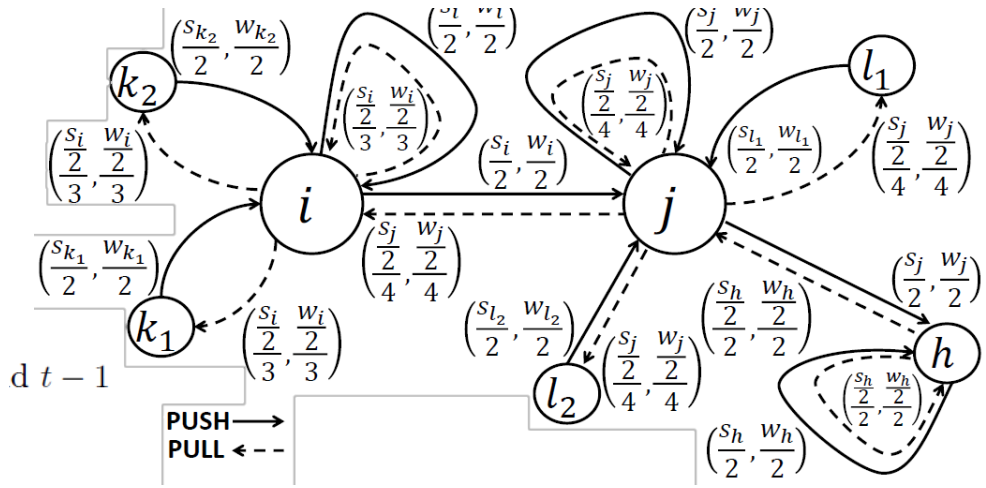
Source picture: https://sensor.community/en/

Self – Stabilized Local Load Balancing

- **Question**
  - Is Push&Pull-Sum a good method for Load Balancing
- LIterature
  - Dinitz, Y., Dolev, S. & Kumar, M. Local Deal-Agreement Algorithms for Load Balancing in Dynamic General Graphs. Theory Comput Syst 67, 348–382 (2023). https://doi.org/10.1007/s00224-022-10097-6
  - Nugroho, S., Weinmann, A., Schindelhauer, C. (2023). Adding Pull to Push Sum for Approximate Data Aggregation. In: Dolev, S., Schieber, B. (eds) Stabilization, Safety, and Security of Distributed Systems. SSS 2023. Lecture Notes in Computer Science, vol 14310. Springer, Cham.
- Contact
  - Christian Schindelhauer
  - Saptadi Nugroho (saptadinugroho at gmail.com)

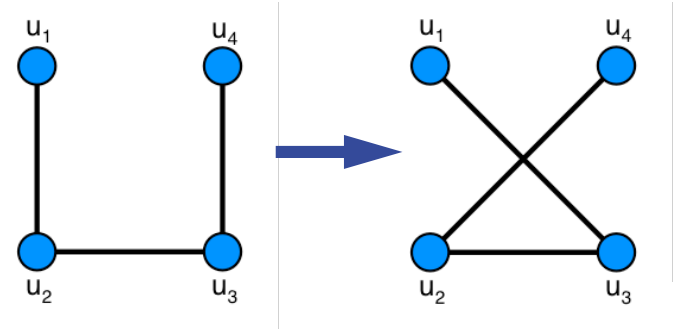


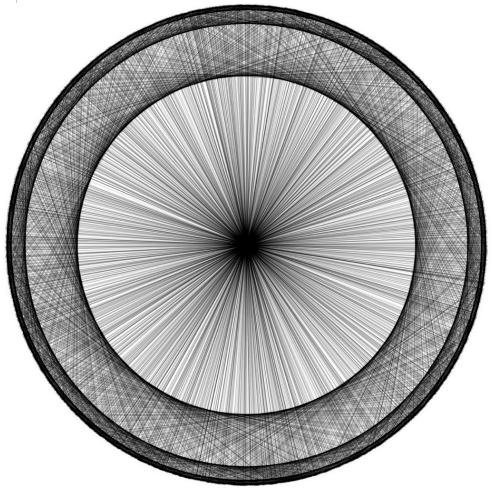




Flipping P2P

- **Task (Theory or Simulations)**
  - Chord/CAN/Pastry/Kademlia Network
  - using Random Flip operations
- **Literature**
  - Lecture P2P-Networks, S., Sommer 2023
  - George Giakkoupis. 2022. Expanders via local edge flips in quasilinear time. In Proceedings of the 54th Annual ACM SIGACT Symposium on Theory of Computing (STOC 2022). Association for Computing Machinery, New York, NY, USA, 64–76. https://doi.org/10.1145/3519935.3520022
- **Supervisors**
  - Christian Schindelhauer (schindel at informatik.uni-freiburg.de)
  - Saptadi Nugroho (saptadinugroho at gmail.com)





Expanders via Local Edge Flips in Quasilinear Time

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ABSTRACT

Mahlmann and Schindelhaue (2005) proposed the following simple process, called *flip-chain*, for transforming any given connected d-regular graph into a d-regular expander: In each step, a random 3-path $abcd$ is selected, and edges ab and cd are replaced by two new edges ac and bd, provided that ac and bd do not exist already. A motivation for the study of the flip-chain arises in the design of overlay networks, where it is common practice that adjacent nodes periodically exchange random neighbors, to maintain good connectivity properties. It is known that the flip-chain converges to the uniform distribution over connected d-regular graphs, and it is conjectured that an expander graph is obtained after $O(nd \log n)$ steps, w.h.p., where n is the number of vertices. However, the best known upper bound on the number of steps is $O(n^2 d^2 \sqrt{\log n})$, and the best bound on the mixing time of the chain is $O(n^{16} d^{36} \log n)$.

We provide a new analysis of a natural flip-chain instantiation, which shows that starting from any connected d-regular graph, for $d = \Omega(\log^2 n)$, an expander is obtained after $O(nd \log^2 n)$ steps, w.h.p. This result is tight within logarithmic factors, and almost matches the conjectured bound. Moreover, it justifies the use of edge flip operations in practice: for any d-regular graph with $d = \text{poly}(\log n)$, an expander is reached after each vertex participates in at most $\text{poly}(\log n)$ operations, w.h.p. Our analysis is arguably more elementary than previous approaches. It uses the novel notion of the *strain* of a cut, a value that depends both on the crossing edges and their adjacent edges. By keeping track of the cut strains, we form a recursive argument that bounds the time before all sets of a given size have large expansion, after all smaller sets have already attained large expansion.

ACM Reference Format:
George Giakkoupis. 2022. Expanders via Local Edge Flips in Quasilinear Time. In *Proceedings of the 54th Annual ACM SIGACT Symposium on Theory of Computing (STOC '22), June 20–24, 2022, Rome, Italy.* ACM, New York, NY, USA, 13 pages. https://doi.org/10.1145/3519935.3520022

1 INTRODUCTION

In [24], Mahlmann and Schindelhaue proposed a very simple and elegant process to transform any given connected d-regular graph into a d-regular expander.[1] This process consists of a sequence of *flip operations*: A flip operation on graph $G = (V, E)$ chooses a 3-path $abcd$ of G u.a.r., and if neither of the edges ac and bd exist already, then edges ab and cd are removed, and are replaced by edges ac and bd; otherwise, the operation does not modify the graph.

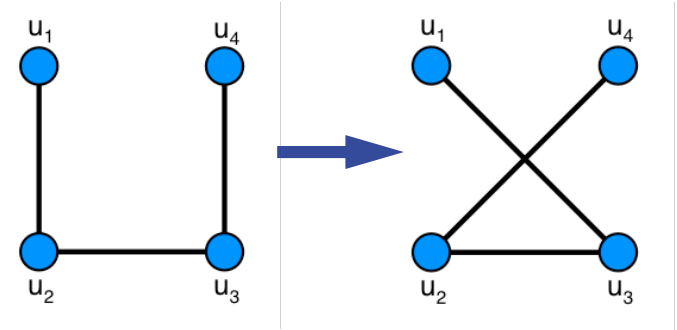
A flip operation does not change the degrees of vertices, and does not disconnect a connected graph. Moreover, it is a very *local* operation, as it affects only four vertices, at distance at most three apart. This is minimal, in the sense that no edge switching operation involving fewer than four vertices preserves the degrees, and the only shallower subgraph than a 3-path is the 3-star, for which there are no degree-preserving operations [6].

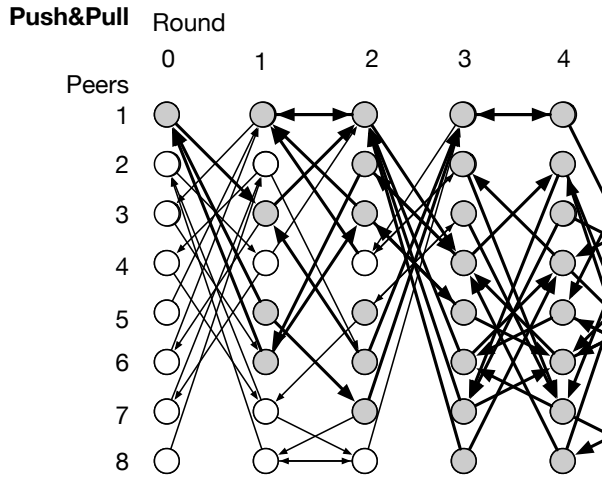
The Markov chain $(G_t = (V, E_t))_{t \in \mathbb{N}_0}$ induced by a sequence of flip operations is called a *flip-chain*, and it converges to the uniform distribution over all connected d-regular graphs on V, if the initial graph $G_0 = (V, E_0)$ is connected and d-regular [24]. Moreover, based on experimental evidence, it has been conjectured that $t = O(nd \log n)$ operations suffice to ensure that graph G_t is an expander w.h.p. [23, 24].

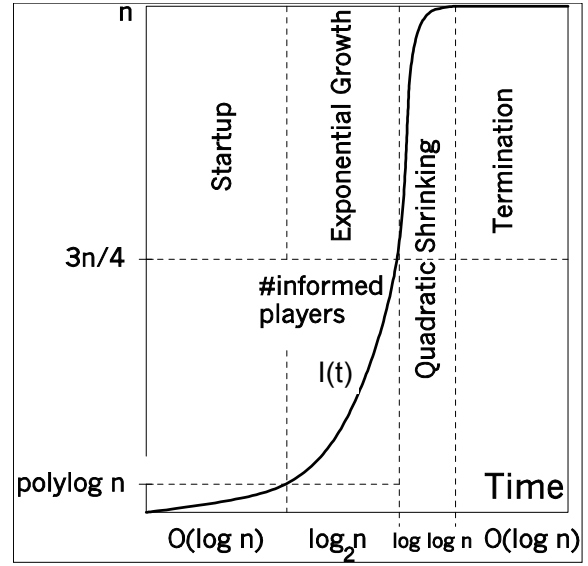
A motivation for the study of flip-chains arises in the design of

Rumor Spreading and Graph Transformation

- **Tasks (theory/simulations)**
  - Combine Rumor Spreading with Random Graph Transformations
  - Distributed Connectivity Tester
- **Literature**
  - Lecture P2P-Networks, S., Sommer 2023
  - George Giakkoupis. 2022. Expanders via local edge flips in quasilinear time. In Proceedings of the 54th Annual ACM SIGACT Symposium on Theory of Computing (STOC 2022). Association for Computing Machinery, New York, NY, USA, 64–76.
- **Supervisors**
  - Christian Schindelhauer
  - Saptadi Nugroho (saptadinugroho at gmail.com)





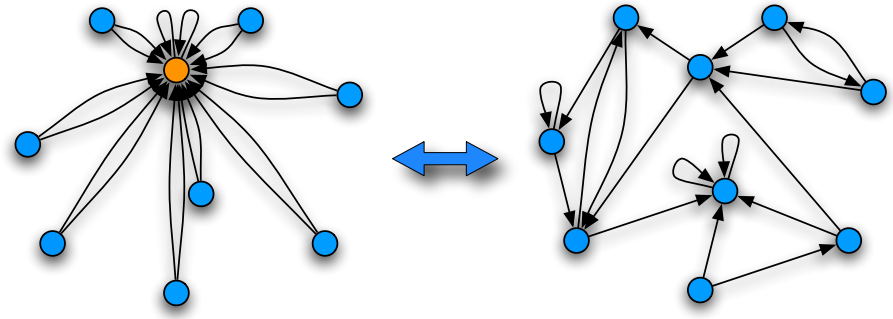


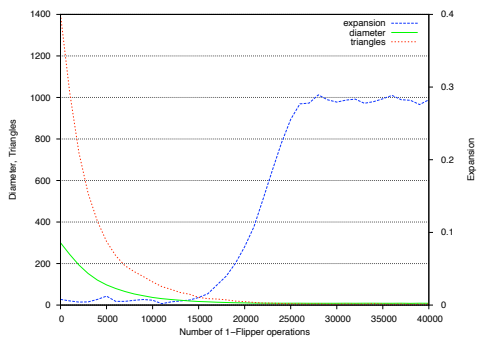
Random Directed Network Operations and Expanders

- **Question**
  - Does Pointer-Push&Pull converge in time O(n log n)
  - Does directed Flipper converge fast?
- Literature
  - Csóka, E., & Grabowski, Ł. (2022). On directed analogues of expander and hyperfinite graph sequences. Combinatorics, Probability and Computing, 31(2), 184-197
  - George Giakkoupis. 2022. Expanders via local edge flips in quasilinear time. In Proceedings of the 54th Annual ACM SIGACT Symposium on Theory of Computing (STOC 2022). Association for Computing Machinery, New York, NY, USA, 64–76.
- Contact
  - Christian Schindelhauer
  - Saptadi Nugroho (saptadinugroho at gmail.com)

Pointer-Push&Pull:

- choose random node $v_1 \in V$
- do random walk v_1, v_2, v_3
- delete edges (v_1,v_2) and (v_2,v_3)
- add edges (v_2,v_1) and (v_1,v_3)





Telocate

Professional Localization

ALISA

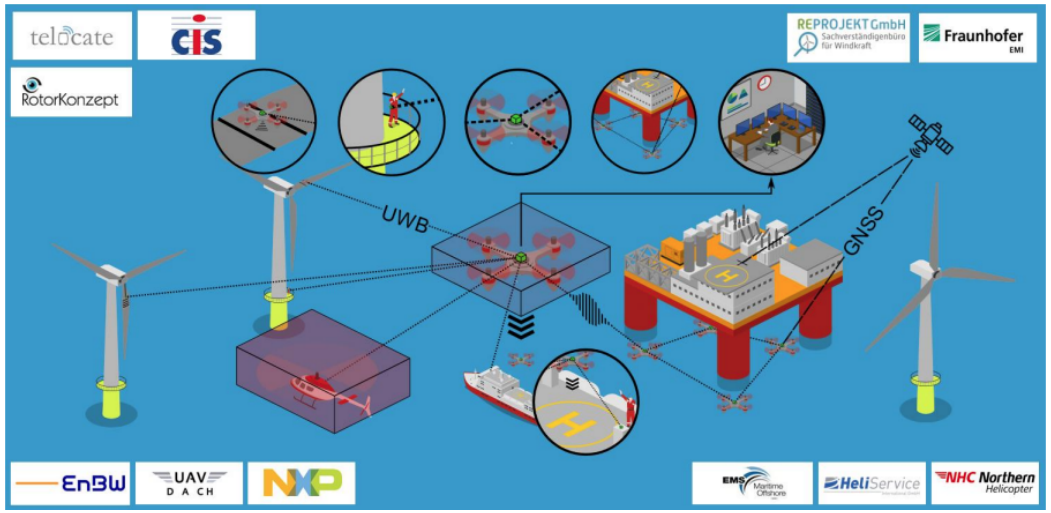
- **AI and Localization Based Picking System with Intelligent Scannerless Work Glove**
  - Goal: optimize logistics, simplify picking process
  - Smart glove with pressure sensors and ultrasound speaker
  - Recognize hand gestures, locate glove
- Contact:
  - Joan Bordoy bordoy at informatik.uni-freiburg.de
  - Johannes Wendeberg

FOOTPRINT

- **Collection of materials, machines and traffic flows for the calculation of the CO2 footprint of road construction site**
- **Goal**
  - Estimate and reduce CO2 footprint of road construction sites
  - Ultra-wideband (UWB) localization, inertial measurement units (IMUs) and GPS to detect machine usage
  - Light Detection and Ranging (LiDAR) to detect traffic
  - Analyze data, fuse sensors, detect inefficiencies
- Contact:
  - Joan Bordoy bordoy at informatik.uni-freiburg.de
  - Johannes Wendeberg

LoCA

- **Safe UWB-based localization and collision avoidance in offshore wind farms for installation, inspection and maintenance**
- **Goal**
  - Drone localization and collision avoidance in offshore wind farms
  - Distance measurements (UWB) to infrastructure and other drones
  - Robust algorithm, error analysis, error reduction using other drones
- Contact:
  - Joan Bordoy bordoy at informatik.uni-freiburg.de
  - Johannes Wendeberg

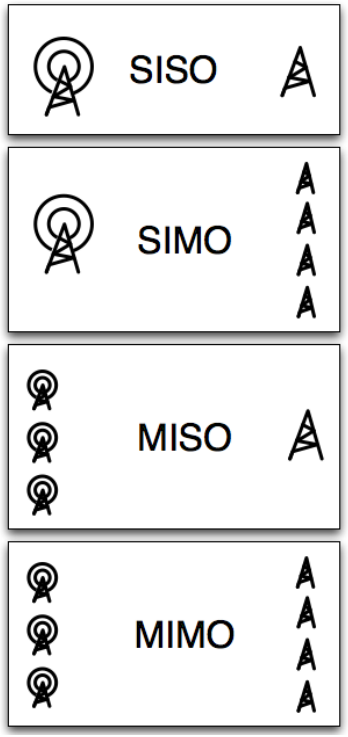


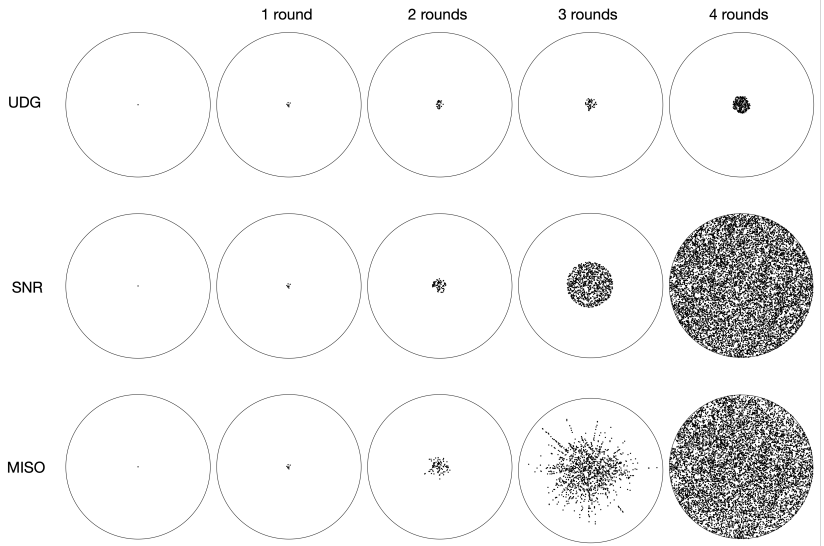
MIMO and Near-Field

Understanding the physical foundations of communication

MIMO

- Tasks (theoretically/practical)
  - Is there a MIMO-Multicast with Multiplexing Gain
  - Parallel broadcast in 3D
  - Concurrent Multicast with multiplexing gain/diversity gain tradeoff
- Literature
  - S., C., Oak, A. and Janson, T., 2019, September. Collaborative Broadcast in Rounds. In International Symposium on Algorithms and Experiments for Sensor Systems, Wireless Networks and Distributed Robotics (pp. 119-136). Cham: Springer International Publishing.
  - S., Lecture Algorithms for Wireless Communication, 2022
  - Thomas Janson, Energy-Efficient Collaborative Beamforming in Wireless Ad Hoc Networks, 2015
  - Tim Mugele, Simulation and Analysis of Different Variants of a Collaborative Broadcast Algorithm Regarding Different Path-Loss-Models, Bachelor Thesis, 2020
- Supervisor:
  - Christian Schindelhauer & Peter Krämer

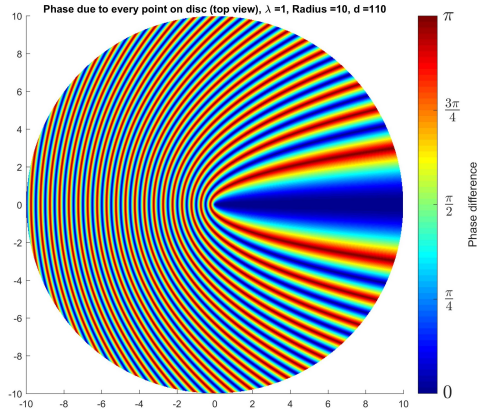




- MIMO capacity (with waterfilling)

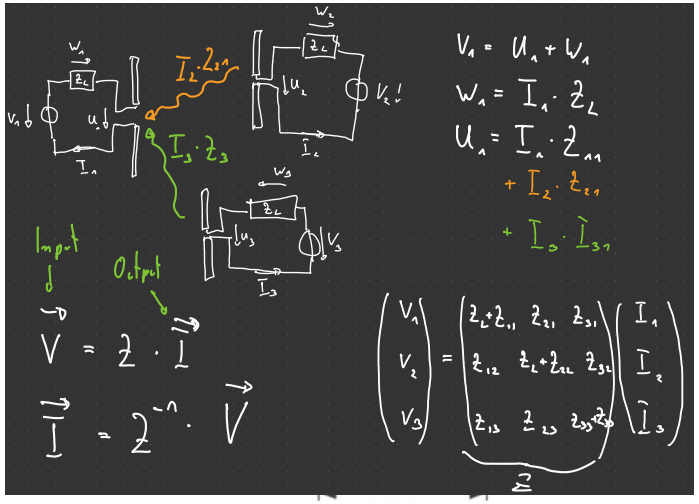
$$C = \sum_{i=1}^{n_{\min}} \log_2 \left(1 + \frac{P_i \lambda_i^2}{N_0} \right)$$

- with $P_i = \left[\mu - \frac{N_0}{\lambda_i^2} \right]^+$



Near-Field Antenna Fields

- Questions
  - Test of the validity of near-field models
  - Do Near-Field models scale?
- Tasks
  - Simulation of linear array in the Near-Field
  - Finding worst case position for near-field communication
  - General Near-Field-Simulator
- Literature
  - Abhishek Sharma, Analyzing the Properties of Near-Field Coupling Matrices for Large Antenna Systems, Master Thesis 2022
- Supervisor:
  - Christian Schindelhauer & Peter Krämer



Zuhrt's Model

$$Z_{nm} = R_{nm} + iX_{nm}$$

$$A = k_0\sqrt{a^2+b^2}+b \qquad \bar{A} = k_0\sqrt{a^2+b^2}-b$$

$$B = k_0\sqrt{a^2+(b-l)^2}+(b-l) \qquad \bar{B} = k_0\sqrt{a^2+(b-l)^2}-(b-l)$$

$$C = k_0\sqrt{a^2+(b+l)^2}+(b+l) \qquad \bar{C} = k_0\sqrt{a^2+(b+l)^2}-(b+l)$$

$$\frac{8\pi R_{nm}}{Z_0} = -\cos(k_0 b)\left[-2\mathrm{Ci}(A)-2\mathrm{Ci}(A')+\mathrm{Ci}(B)+\mathrm{Ci}(B')+\mathrm{Ci}(C)+\mathrm{Ci}(C')\right]+$$
$$+\sin(k_0 b)\left[2\mathrm{Si}(A)-2\mathrm{Si}(A')-\mathrm{Si}(B)+\mathrm{Si}(B')-\mathrm{Si}(C)+\mathrm{Si}(C')\right]$$

$$\frac{8\pi X_{nm}}{Z_0} = -\cos(k_0 b)\left[2\mathrm{Si}(A)+2\mathrm{Si}(A')-\mathrm{Si}(B)-\mathrm{Si}(B')-\mathrm{Si}(C)-\mathrm{Si}(C')\right]+$$
$$+\sin(k_0 b)\left[2\mathrm{Ci}(A)-2\mathrm{Ci}(A')-\mathrm{Ci}(B)+\mathrm{Ci}(B')-\mathrm{Ci}(C)+\mathrm{Ci}(C')\right]$$

Hertz's Model

$$Z_{nm} = \frac{3}{2}R_{nn}\left[\left(\frac{sinx}{x}+\frac{cosx}{x^2}-\frac{sinx}{x^3}\right)+j\left(\frac{cosx}{x}-\frac{sinx}{x^2}-\frac{cosx}{x^3}\right)\right]$$

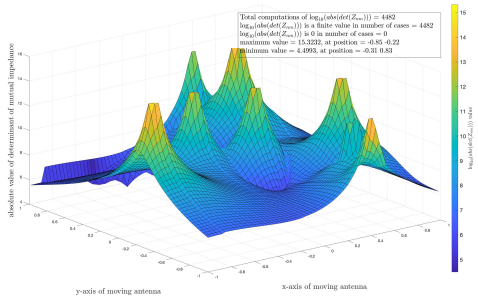


Figure 20: 3D surface plot of the computations of the logarithm of the absolute value of the $|Z_{nm}|$ is plotted against all the possible positions with respect to the 8 fixed dipoles in all of the instances.

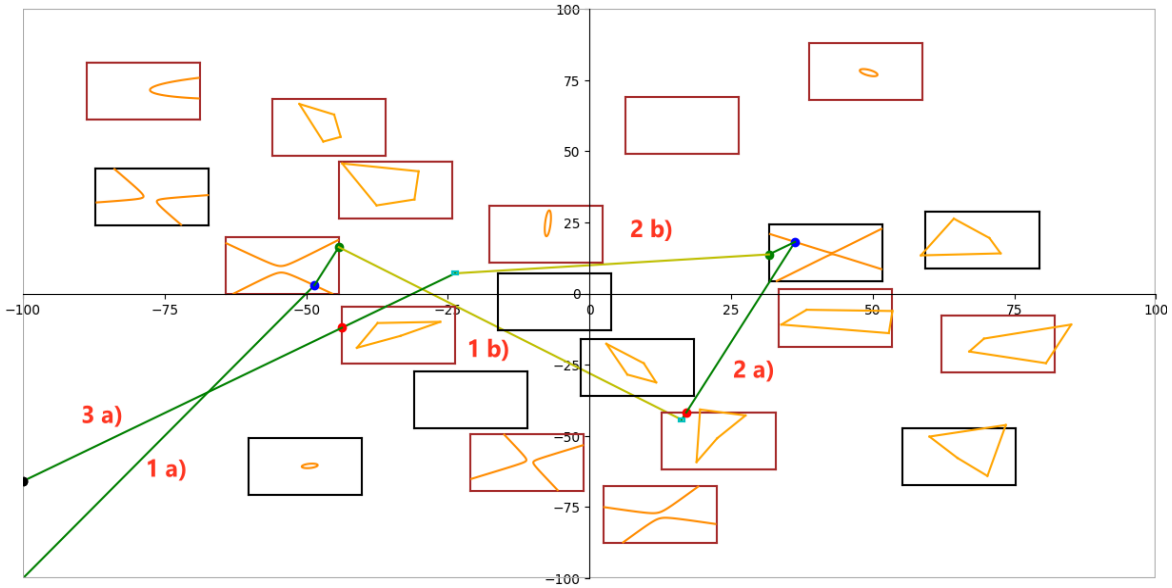
Visual Cryptography

Harvesting the Complexity of Mirrors for Encryption

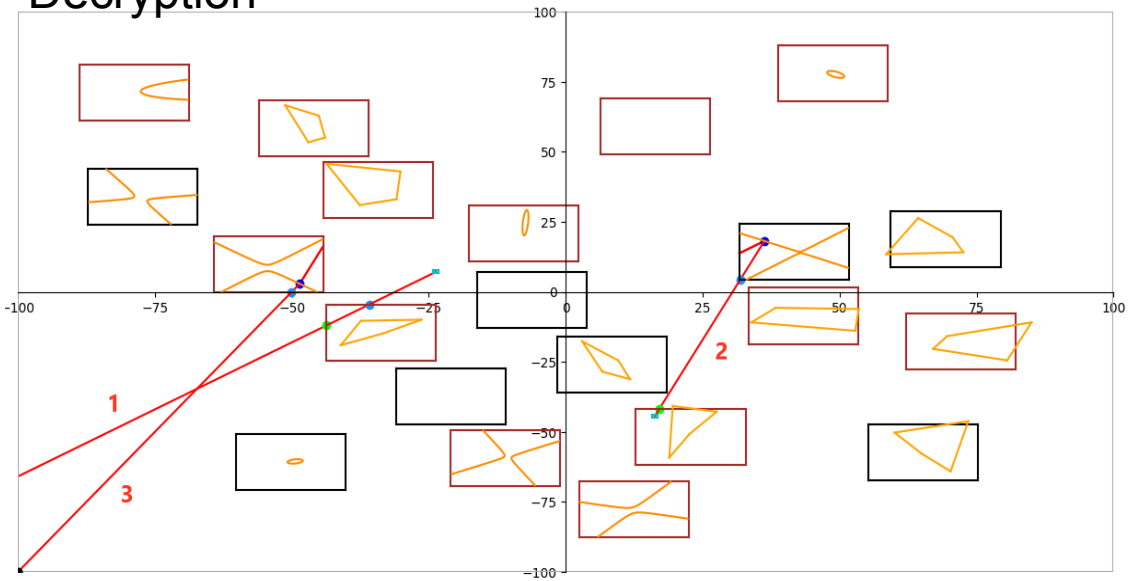
Visual Cryptography

- Cryptography based on **Ray Tracing**
  - of a light ray through a 2D/3D setup
- **Optical** objects in 2D cartesian coordinates
  - Parabola, Hyperbola, Line segments
  - as well as generic 1st, 2nd and 3rd degree objects
- Light ray
  - **reflected** or **refracted** from objects
  - pass through non-optical, Boolean logic gates
    - like XOR, Matrix-Mix and NOT-Shift
- Together they from a complex symmetric key crypto system
- **Literature**:
  - Mohanty, Peairs, S., „Introducing Gate Based Ray Tracing Cryptography“, EasyChair Preprint no. 10450, 2023

Encryption

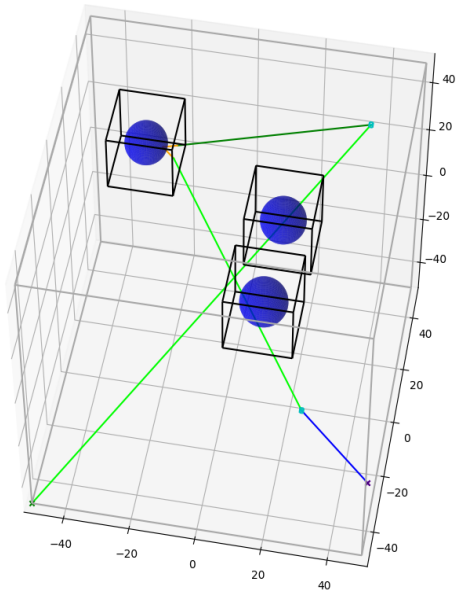


Decryption

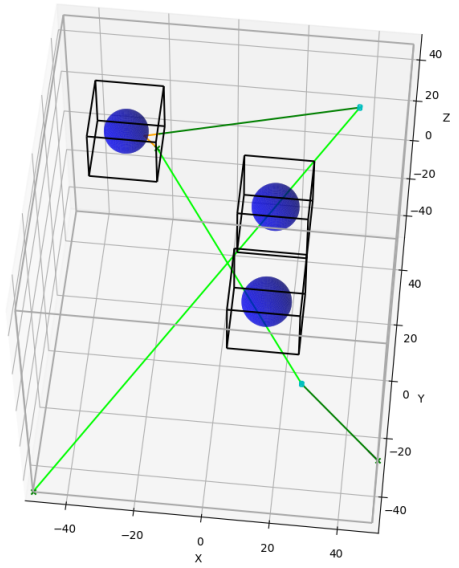


Task: Extension to 3D

- Extension to 3D cartesian coordinate system
- inclusion of new objects such as
  - sphere
  - hyperboloid
  - paraboloid and
  - generic 3D objects#
- Contact
  - Sneha Mohanty (mohanty.at.informatik.uni-freiburg.de)



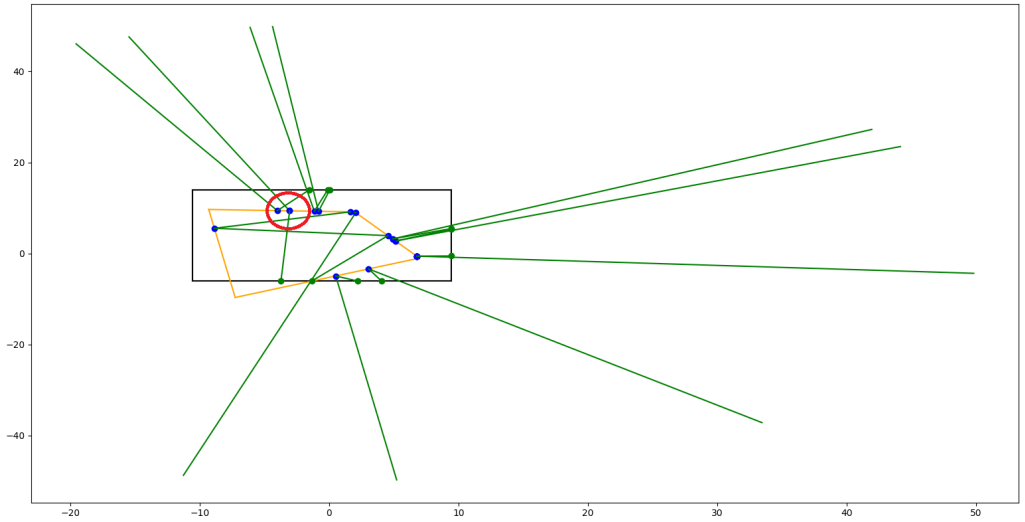
Encryption



Decryption

Task Designing Attacks

- Single reflection case
  - Interpolation of object hit-points to ‘compute’ object
  - Lagrangian, Newtonian and Spline-based technique comparisons
- Multiple reflection and refraction case
  - Use Bounding Volume Hierarchies to detect multiple collisions in a sub-region
- Contact
  - Sneha Mohanty (mohanty.at.informatik.uni-freiburg.de)



Cryptography

Mental Card Games and Peer-to-Peer

Bullet Proofs for Mental Card Games

- Tasks
  - Given a formal description of a card game
    - automatically construct all interactive zero-knowledge games for playing the game only (without trusted third party)
    - Design an interpreter/compile which translate card game languages into interactive proof systems
  - Implement the most efficient Mental Card Game
- Supervisor:
  - Christian Schindelhauer

Theses and Projects at CoNe
Thanks for your Attention

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