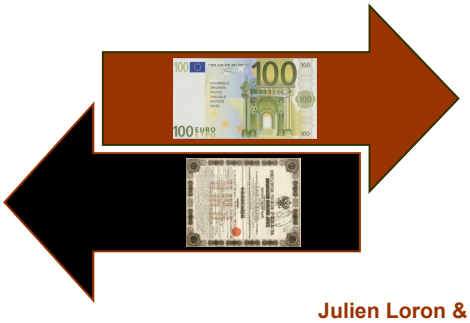
Bank of Finland's Sixth Seminar on Payment Systems Simulation
Helsinki, August 2008

Optimisation strategy in a DvP model 1 Securities Settlement System



Julien Loron & Fabien Renault
Banque de France

The views expressed in this presentation are those of the authors only, and may not represent the views of Banque de France

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Overview

- Rationale for investigating SSS optimisation
- Objectives and tools
- Research Questions
  1. What are the best offsetting algorithms ?
  2. Mono ISIN Vs Multi ISIN approach
  3. Multi, Tri or Bilateral approach
  4. Continuous Vs Batch approach
- Conclusions

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Rationale for investigating SSS optimisation

Oversight of SSS systems

- Efficient optimisation means lower liquidity needs (lower liquidity costs), and/or lower settlement delay (potentially safer)
- By studying optimisation, the overseers can better assess if the operators have put in place efficient settlement procedures

Development of the T2S system

- *"On 17 July 2008, the Governing Council of the European Central Bank decided to launch the TARGET2-Securities (T2S) project and to provide the resources required until its completion. It also decided to assign the development and operation of T2S to the Deutsche Bundesbank, the Banco de España, the Banque de France and the Banca d'Italia".* (Governing Council press release)
- As operator of T2S, the Eurosystem should be able to provide the market with an efficient system

Importance of optimisation in SSS and RTGS

- SSS are often less liquid than RTGS. As a consequence optimization plays a greater role in SSS...

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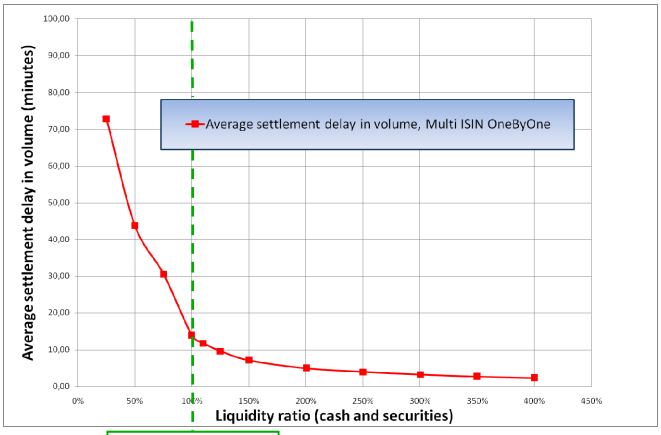
Rationale for investigating SSS optimisation

Example: We simulate the case of a generic SSS (random data)

- Full day, 20 000 transactions,100 participants, 30 ISIN
- Real time settlement, optimisation every 1 hour
- Liquidity level varied from 25% to 400%
- Settlement delay is recorded



Liquidity needed to settle all transactions

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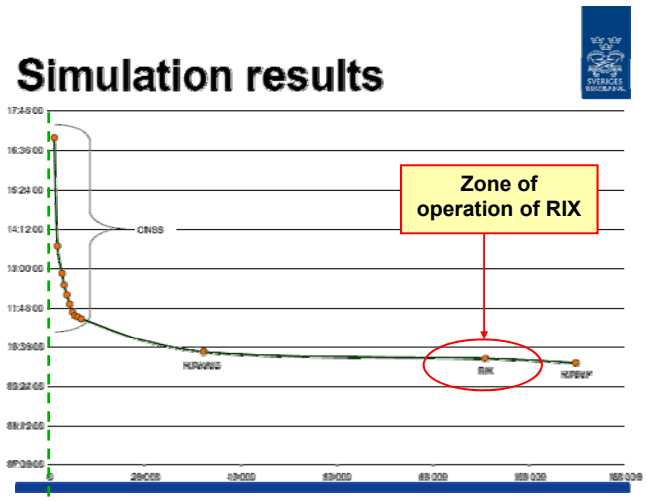
Rationale for investigating SSS optimisation

Comparing with similar results obtained on a real RTGS by Segendorff (2004)…



Liquidity needed to settle all transactions

Taken from Segendorff, Sveriges Riksbank, 2004

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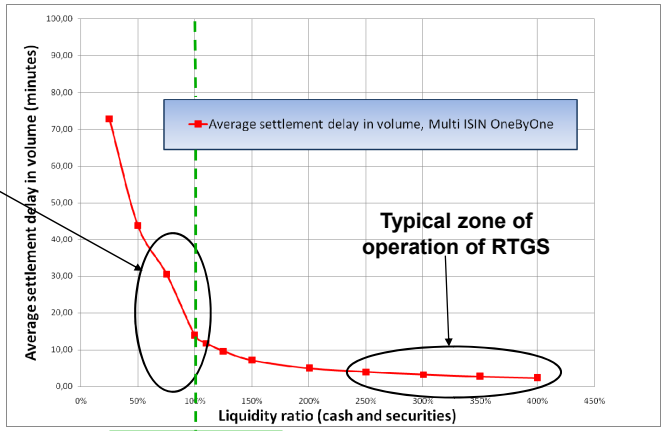
Typical zone of operation of SSS



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Example: We take the case of a generic SSS (random data)

- Full day, 20 000 transactions,100 participants, 30 ISIN
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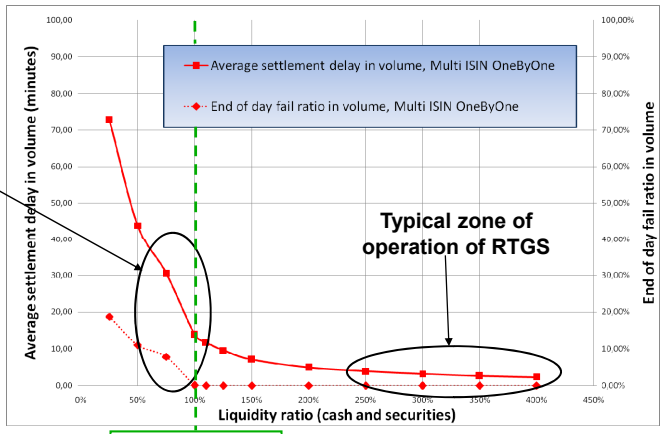
- Liquidity level varied from 25% to 400%
- Settlement delay and end of day fail ratio are recorded

Typical zone of operation of SSS



Liquidity needed to settle all transactions

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Rationale for investigating SSS optimisation

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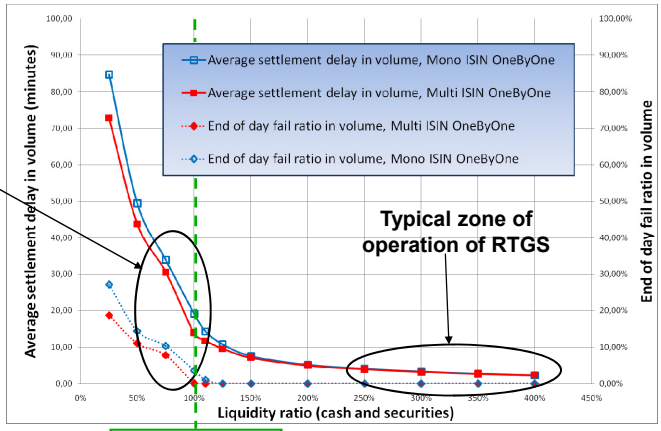

Liquidity needed to settle all transactions

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Objectives and tools

- **Objectives of SSS optimization (alternatively):**
  - Lowest settlement delay in volume (number of transactions)
  - Lowest settlement delay in value
  - Lowest end-of-day fail ratio in volume
  - Lowest end-of-day fail ratio in value
- An adequate balance is to be found between these four (sometimes antinomic) objectives
  - *"With respect to the level of priority of instructions and their intended settlement dates, T2S should maximize the volume (number of instructions) and the overall value of settlements, by trying to find out an optimum balance between the two."* (T2S market consultation TG3, July 2007)
- **Available tools to increase SSS efficiency:**
  - Self-collateralization (on stock and/or on flows)
  - Partialization of the trades
  - **Offsetting mechanisms**

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RQ 1: What are the best algorithms?

- We consider a batch of 200 DvP transactions bearing on a single ISIN between 2 participants. We let the liquidity level vary
- Which algorithm will perform best (settle most in value and/or volume) in this bilateral Mono ISIN optimisation ?

- Algorithm1 : Greedy
- Algorithm 2: One By One
- Algorithm 3 : FIFO
- Algorithm 4: Robin Hood
- Algorithm 5: Las Vegas Greedy
- Algorithm 6 : Greedy^2 / Greedy^4

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RQ 1: What are the best algorithms?

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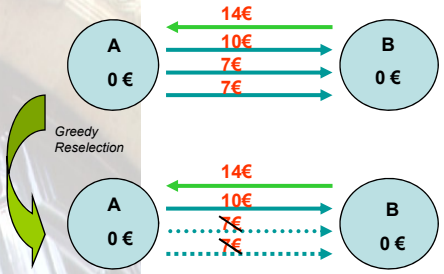
Greedy Algorithm



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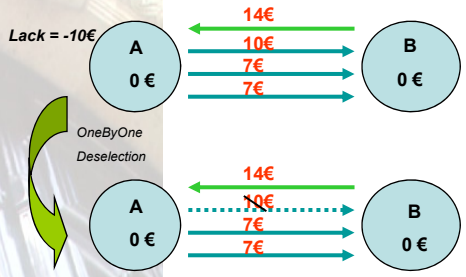
One By One Deselect Algorithm



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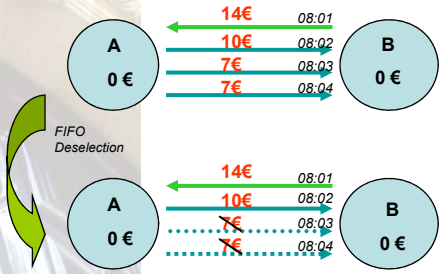
FIFO Algorithm



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- **Algorithm 3 : FIFO**
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- We consider a batch of 200 DvP transactions bearing on a single ISIN between 2 participants. We let the liquidity level vary
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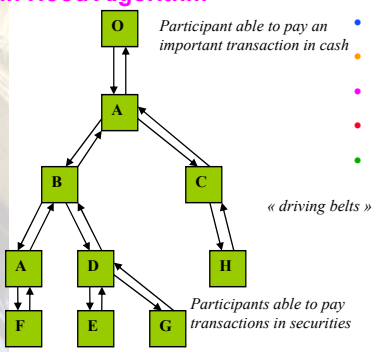
Robin Hood Algorithm



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- **Algorithm 4: Robin Hood**
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Las Vegas Greedy Algorithm

- Algorithm1 : Greedy
- Algorithm 2: One By One
- Algorithm 3 : FIFO
- Algorithm 4: Robin Hood
- **Algorithm 5: Las Vegas Greedy**
- Algorithm 6 : Greedy^2 / Greedy^4

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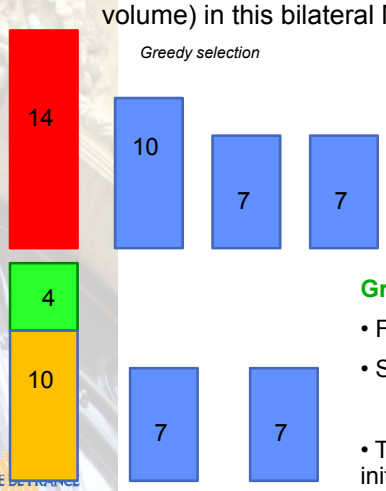

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- **Algorithm 6 : Greedy^2 / Greedy^4**

Greedy^2 Algorithm

- First step: Greedy selection on initial set
- Second step: Greedy launched on subset
  - « Sub-Greedy » finds a solution
- Third step: Transactions are exchanged in the initial set

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RQ 1: What are the best algorithms?

- We consider a batch of 200 DvP transactions bearing on a single ISIN between 2 participants. We let the liquidity level vary
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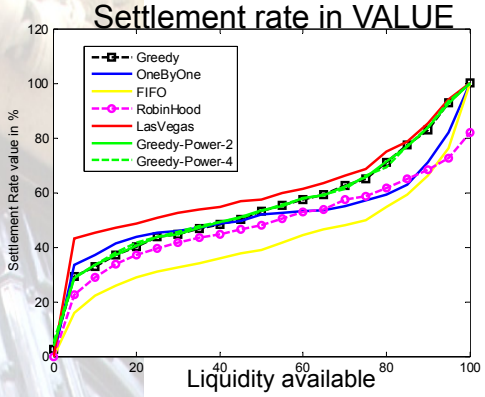
Settlement rate in VALUE



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Standings in Value
1. Las Vegas Greedy
2. Greedy^2 / Greedy^4
3. Greedy
4. One By One

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RQ 1: What are the best algorithms?

- We consider a batch of 200 DvP transactions bearing on a single ISIN between 2 participants. We let the liquidity level vary
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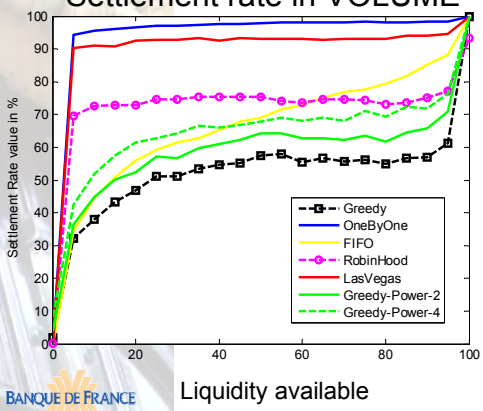
Settlement rate in VOLUME



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Standings in Volume
1. One By One
2. Las Vegas Greedy
3. Robin Hood
4. FIFO

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RQ 1: What are the best algorithms?

- We consider a batch of 200 DvP transactions bearing on a single ISIN between 2 participants. We let the liquidity level vary
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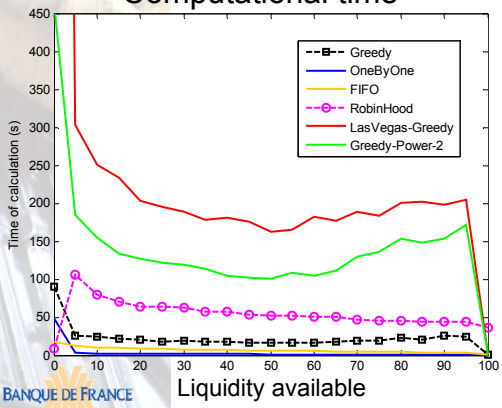
Computational time



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Standings in Speed
1. One By One
2. FIFO
3. Greedy
4. Robin Hood

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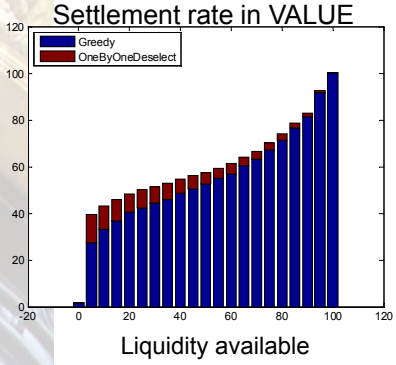
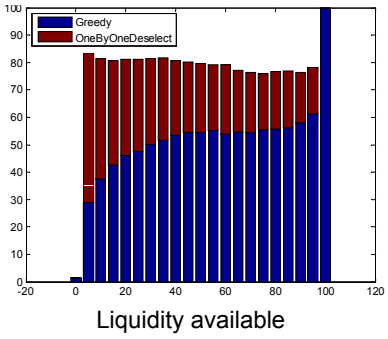
RQ 1: What are the best algorithms?

- Some algorithms complement each other in an efficient manner
- Launching them alternatively may provide an edge over a monoculture approach

Settlement rate in VALUE



Settlement rate in VOLUME



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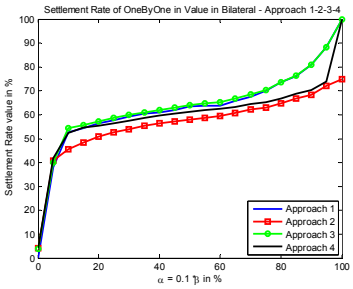
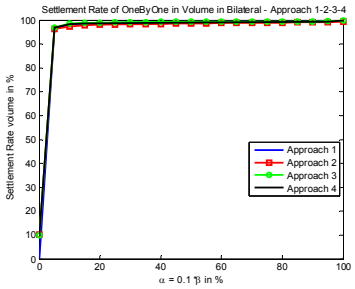
RQ 2: Mono ISIN Vs Multi ISIN approach

- We consider a batch of 200 DvP transactions bearing on 3 different ISIN between 2 participants (averaged over 500 draws)
- **Bilateral OneByOne** is used, **Cash-poor** (securities rich) system
- Which approach will settle the most transactions ?
  - Approach 1 : Optimisation Multi-ISIN only
  - Approach 2 : Optimisation Mono-ISIN only
  - Approach 3 : Optimisation Multi-ISIN first then Mono-ISIN
  - Approach 4 : Optimisation Mono-ISIN first then Multi-ISIN

Cash-poor system

- Multi ISIN better
- Combining both approaches does not improve much





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RQ 2: Mono ISIN Vs Multi ISIN approach

- We consider a batch of 200 DvP transactions bearing on 3 different ISIN between 2 participants (averaged over 500 draws)
- **Bilateral OneByOne** is used, **Cash-rich** (securities poor) system
- Which approach will settle the most transactions ?
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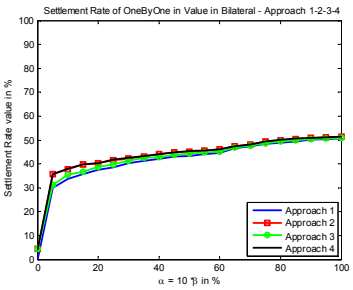
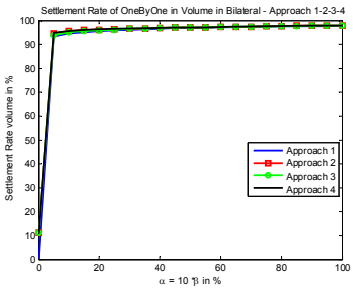
  - Approach 2 : Optimisation Mono-ISIN only
  - Approach 3 : Optimisation Multi-ISIN first then Mono-ISIN
  - Approach 4 : Optimisation Mono-ISIN first then Multi-ISIN

Cash-rich system

- Mono ISIN slightly better
- Combining both approaches does not improve much





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RQ3: Multi, tri or bilateral approach

- **We consider a batch of 1000 transactions between 10 participants that we optimize using a Greedy Mono ISIN algorithm (results averaged over 100 draws)**
- **What is the best approach to lower the fail ratio (value and volume) ?**
  - **Multilateral:** the algorithm is launched once on the set of all participants
  - **Trilateral:** the algorithm is launched for each triplet of participants (120 triplets)
  - **Bilateral:** the algorithm is launched for each pair of participants (45 pairs)
- **…depending on the topology of the transactions**

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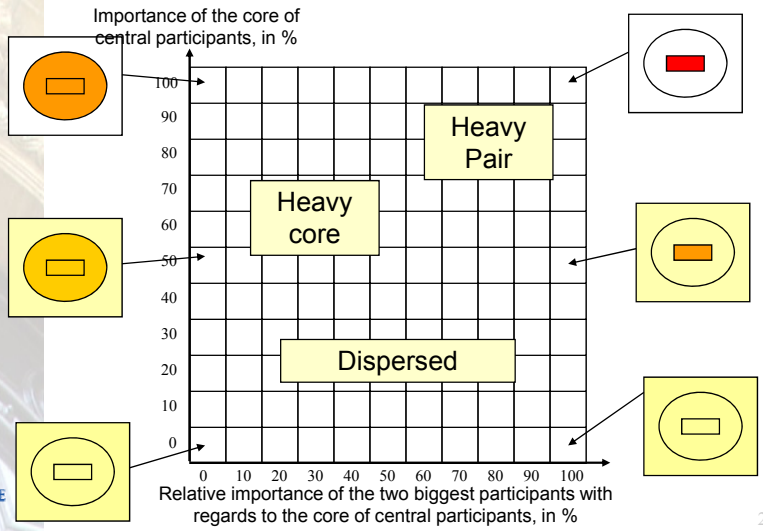
RQ3: Multi, tri or bilateral approach

- **Variation of the topology is investigated on a 11x11 matrix, where the relative importance of the core of central participants and of the central pair is varied**



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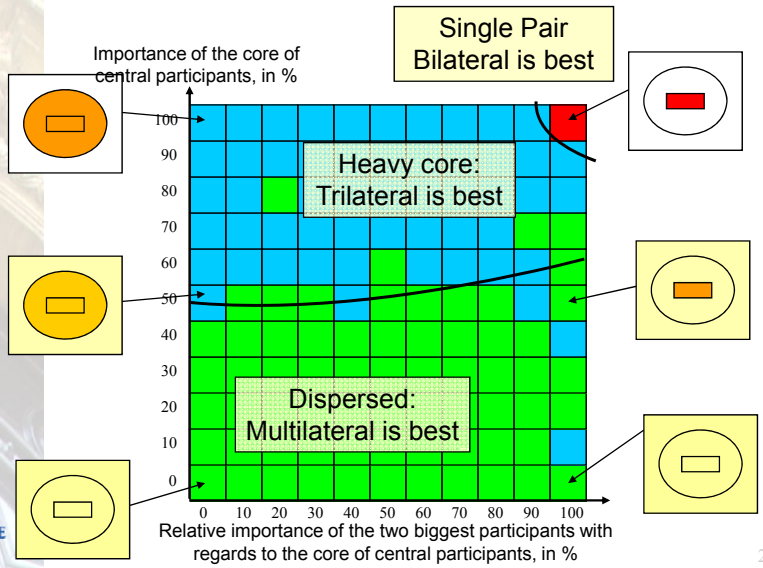
RQ3: Multi, tri or bilateral approach

- **Results in VALUE settled**



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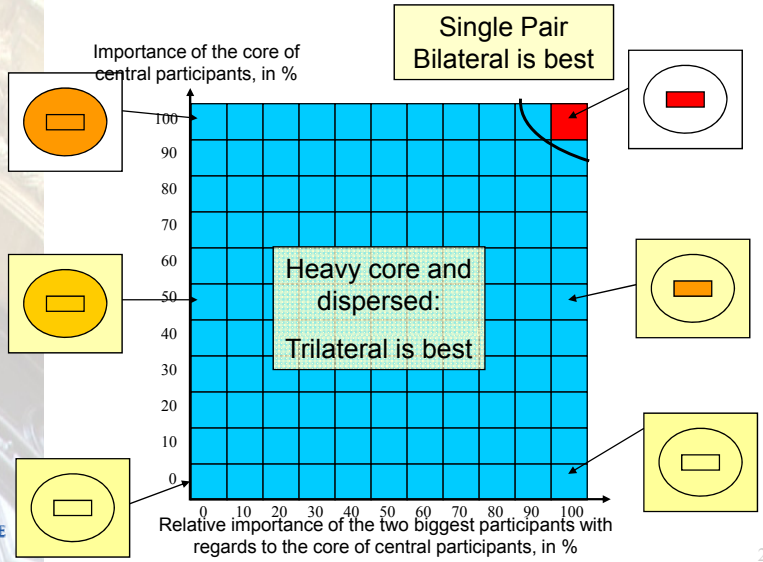
RQ3: Multi, tri or bilateral approach

- **Results in VOLUME settled**



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RQ4: Continuous Vs Batch approach

- **We want to assess the pros and cons of continuous settlement and batch settlement**
  - **Continuous settlement:** Each incoming transaction is immediately attempted for settlement
  - **Batch settlement:** Incoming transactions are directly sent to optimisation
  - In both cases an optimisation algorithm (multilateral multi ISIN One By One) is launched on the bulk of unsettled transactions

- **Simulations performed on a generic SSS**
  - 20 000 transactions with 30 ISIN and 100 participants

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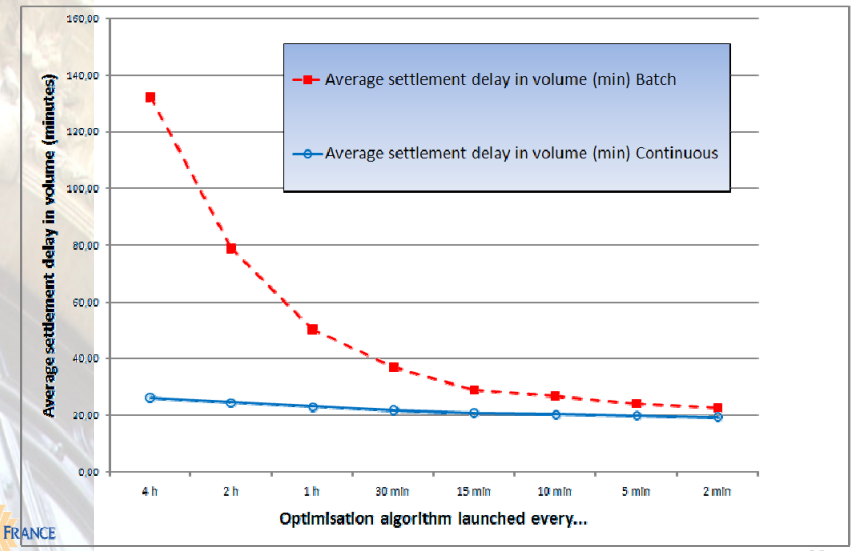
RQ4: Continuous Vs Batch approach

- **Settlement delay and end of day fail ratio in volume**



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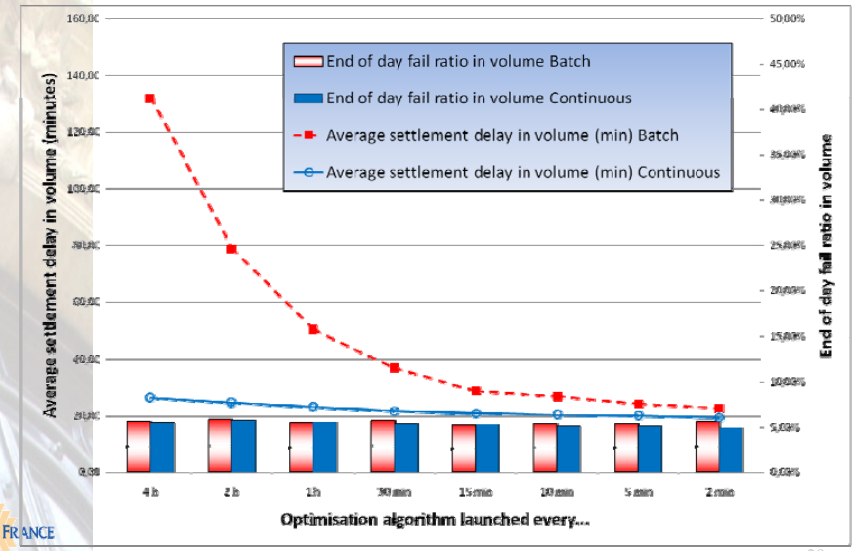
RQ4: Continuous Vs Batch approach

- **Settlement delay and end of day fail ratio in volume**



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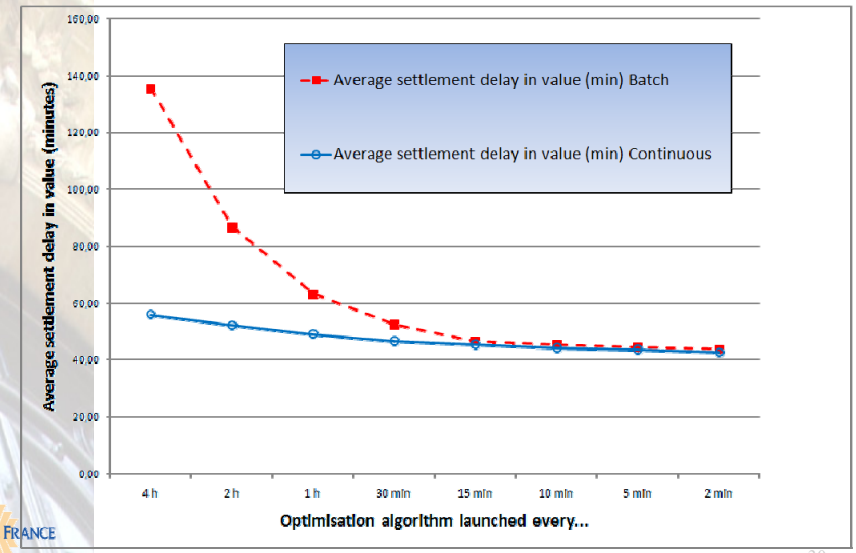
RQ4: Continuous Vs Batch approach

- **Settlement delay and end of day fail ratio in value**



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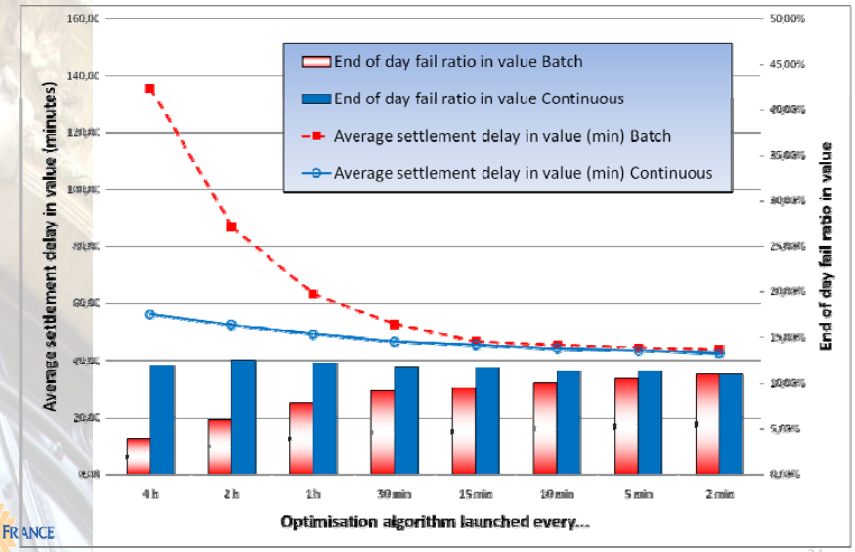
RQ4: Continuous Vs Batch approach

- **Settlement delay and end of day fail ratio in value**



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Conclusions (provisional)

- **RQ1 What are the best offsetting algorithms ?**
  - **OneByOne is well balanced**
  - **If value matters most, Greedy is most adequate**
  - **More advanced algorithms (LV Greedy or Greedy^4) can improve, especially in a batch optimisation, but at a certain CPU cost**
  - **Combining various algorithms should allow for a robust and efficient optimisation**

- **RQ2 Mono ISIN Vs Multi ISIN approach**
  - **Multi ISIN is more suited for cash poor (securities rich) systems**
  - **Mono ISIN is more suited for cash rich (securities poor) systems**
  - **Usually, Mono ISIN performs best for very low liquidity levels (especially true for Greedy algorithms, not shown here)**

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Conclusions (provisional)

- RQ3 Multi, tri or bilateral approach
  - Results (on Greedy and OneByOne, not shown) tend to confirm intuition that
    - Trilateral is best in value in case of "heavy core"
    - Multilateral is best in value when "dispersed"
  - Trilateral is also best in terms of volume (Greedy)
  - Multilateral is fastest. Trilateral slowest
  - Results probably very dependent on topology

- RQ4 Continuous Vs Batch approach
  - A batch approach can win an edge over a continuous approach with regards to the end-of-day fail ratio in value (Threefold reduction)… at the expense of the settlement delay
  - Batch approach can be advised for night settlement

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Conclusions (provisional)

- Best answers depend
  - on the situation (level of liquidity, cash/securities rich, topology…)
  - on the objectives (fail ratio vs delays, value vs volume)

- Options for a complete engine
  - Build a robust engine
    - Supposed to be efficient in every situation
  - Build a configurable engine
    - To be fitted by system operators periodically
  - Build a smart engine
    - "Understand" the situation and launch the adequate strategies

- The different RQ are entangled

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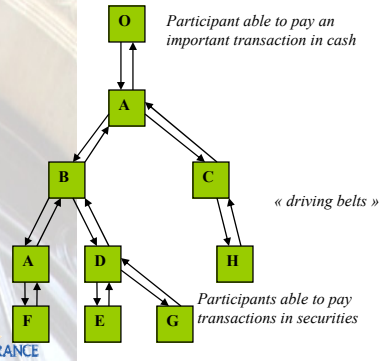
Annex: details on the algorithms used

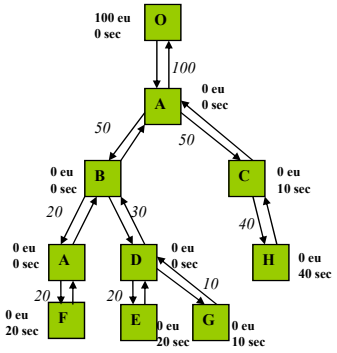
– **Robin Hood Algorithm**

– Select the most important transaction that doesn't create any lack for the resource considered.

– Create a tree of redistribution of the resource.

– Check if it has not created any lack for the counter-resource.





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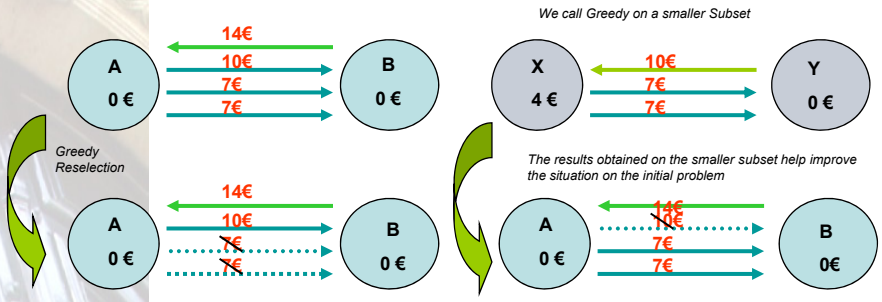
Annex: details on the algorithms used

– **The Greedy power algorithm**

– Recursive Algorithm: Greedy^2 calls Greedy on a smaller subset of transactions. Similarly, Greedy^3 calls Greedy^2 on a smaller subset of transactions…

– It helps to solve the problem when the series of amounts are not super-increasing



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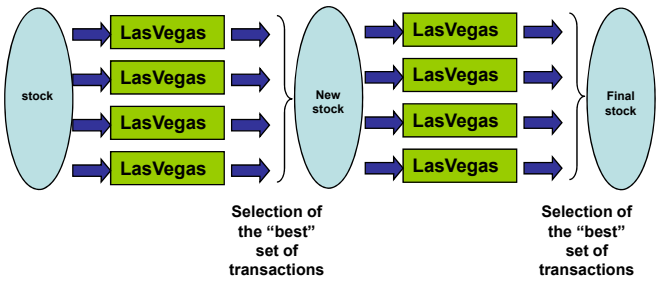
Annex: details on the algorithms used

- **The Las Vegas Greedy algorithm**
  - When reselecting transactions on a lack, and if we don't have a super-increasing series of amounts, we reselect the transactions according to a certain probability
  - Launching the algorithm several times allows for an increased efficiency



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