From PNS to TARGET2: the cost of FIFO in RTGS payment systems

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Presentation Layout

I. Offsetting algorithms
II. Bilateral optimization
    a) Standard offsetting algorithms (PNS/TARGET2)
    b) Non-Fifo advanced algorithms
III. Multilateral optimization
    a) Standard offsetting algorithms (PNS/TARGET2)
    b) Non-Fifo advanced algorithms
IV. Application 1 : Settlement of an AS after a disaster
V. Application 2 : Mitigating the consequences of a technical default in the French LVPS PNS

Offsetting algorithms

- Introduced in RTGS to lower the liquidity needs of the system in normal operation
- Can also be used in order to mitigate crisis situation
- Balance computational time / efficiency
- NP hard problem ➔ Heuristic algorithms
- FIFO (“First In First Out”) or not FIFO ?
  - PNS and T2 Already not FIFO in many ways
    - MUST in PNS / Normal payments in T2
    - FIFO only valid on a bilateral basis
  - FIFO not algorithm dependant

Bilateral optimization
Standard offsetting algorithms

- Same in PNS and in TARGET2
- 2 equivalent constraints (position and bilateral limit)
- Pure FIFO
- Starts with all payments selected and unselect the last payment of the participant in deficit

	A	B
Position	10	10
Queued payments between A and B	500	20
	20	20
	20	20
	20	20

- No payment settled with PNS/T2 algorithm

Bilateral optimization
Non-fifo advanced offsetting algorithms

- Greedy algorithm (Güntzer et al., 1998)
- Non-FIFO
- Starts with all payments selected
- Unselect all payments from the participant in deficit.
- Reselect the payments from the biggest to the smallest.

	A	B
Position	10	10
Queued payments between A and B	500	20
	20	20
	20	20
	20	20

- Success

Bilateral optimization
Non-fifo advanced offsetting algorithms

- Greedy algorithm gives the best solution (in value) for superincreasing payment values.
- If the payment queued are not superincreasing, Greedy will not necessarily provide a good solution.

	A	B
Position	5	5
Queued payments between A and B	140	20
		20
		30
		100

- No payment settled with Greedy algorithm

Bilateral optimization
Non-fifo advanced offsetting algorithms

- 1st tentative to improve on Greedy:
- Greedy++ : after each Greedy iteration, call a subfunction looking for the best solution using the 10 payments closest to the error. (Test every possibility, 1024 in total)

	A	B
Position	5	5
Queued payments between A and B	140	20
		20
		30
		100

- Greedy++ : error 30, send the 10 closest payments to the subfunction.
- Payment 30 is unselected. Success

Bilateral optimization
Non-fifo advanced offsetting algorithms

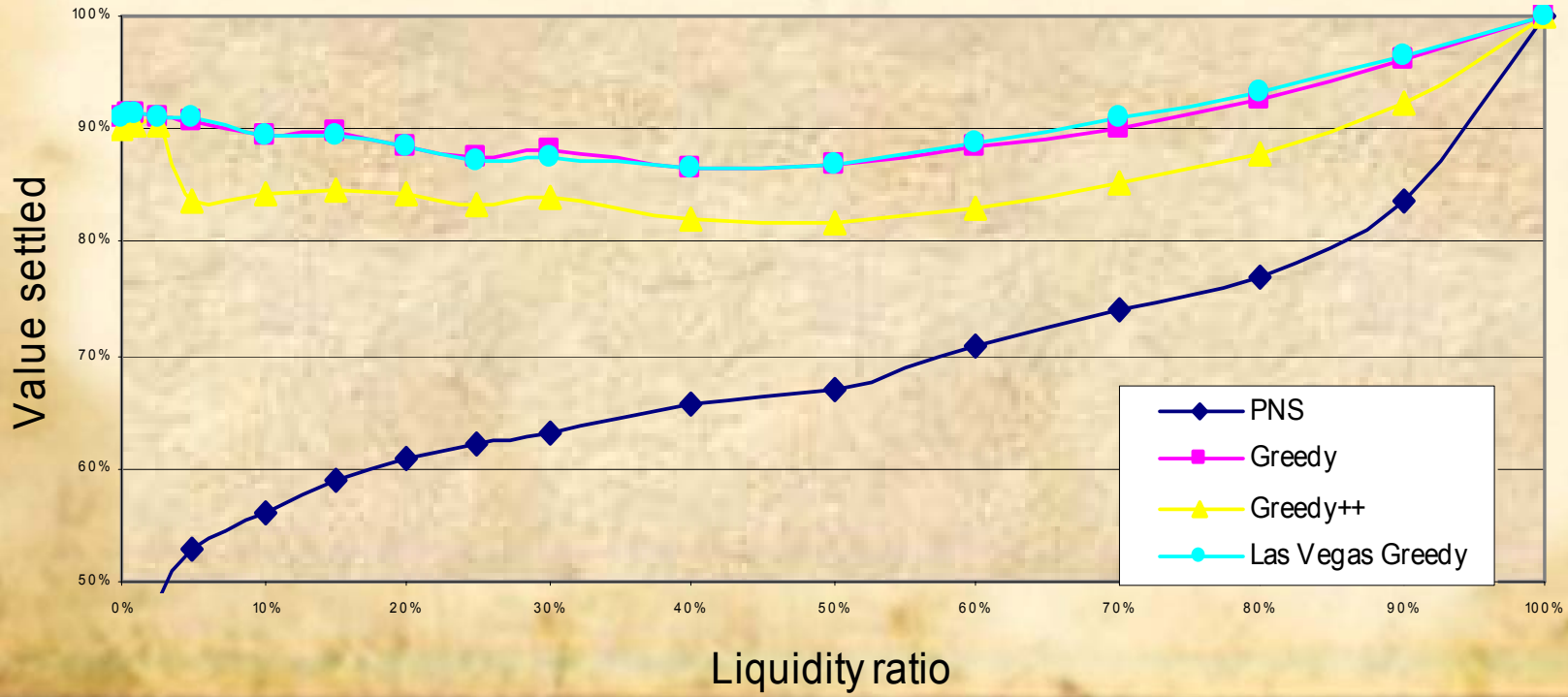
- 2nd tentative to improve on Greedy:
- Las Vegas Greedy : As in Greedy, consider payments in decreasing order.
- When appropriate, select a payment with a given probability. Run the algorithm several times.

	A	B
Position	5	5
Queued payments between A and B	140	20
		20
		30
		100

- Las Vegas Greedy: probability to select 30: 30/(20+20)
- 25% chance to give the good solution. After 10 tries: 95%

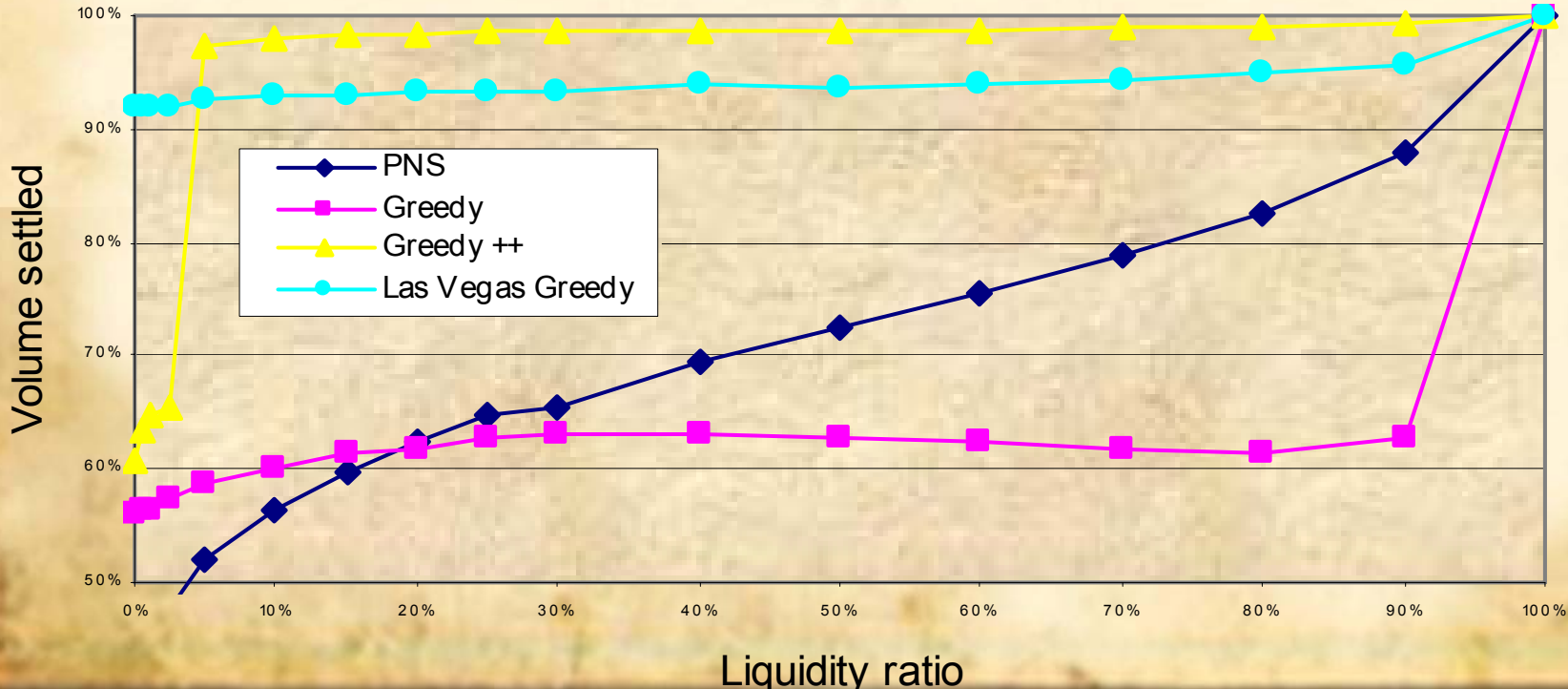
Bilateral optimization
Efficiency of the algorithms: Value

- Efficiency test: 2 participants A and B.
- 100 payments queued from A to B. 100 payments queued from B to A.
- Payments generated randomly (lognormal PNS). Average over 5000 distributions.
- Net receiver has no liquidity. Net emitter has α% of the value needed to settle all payments. Measure the settled value as a % of the maximum possible.
- Las Vegas: stop after 5 unsucessful tries in a row.



Bilateral optimization
Efficiency of the algorithms: Volume

- Efficiency test: 2 participants A and B.
- 100 payments queued from A to B. 100 payments queued from B to A.
- Payments generated randomly (lognormal PNS). Average over 5000 distributions.
- Net receiver has no liquidity. Net emitter has α% of the value needed to settle all payments. Measure the settled volume as a % of all payments.
- Las Vegas: stop after 5 unsucessful tries in a row.



Multilateral optimization
Standard offsetting algorithms

PNS/T2 multilateral algorithm

- Unselect all payments violating bilateral limits
- Find the participant with the smallest negative virtual position

PNS

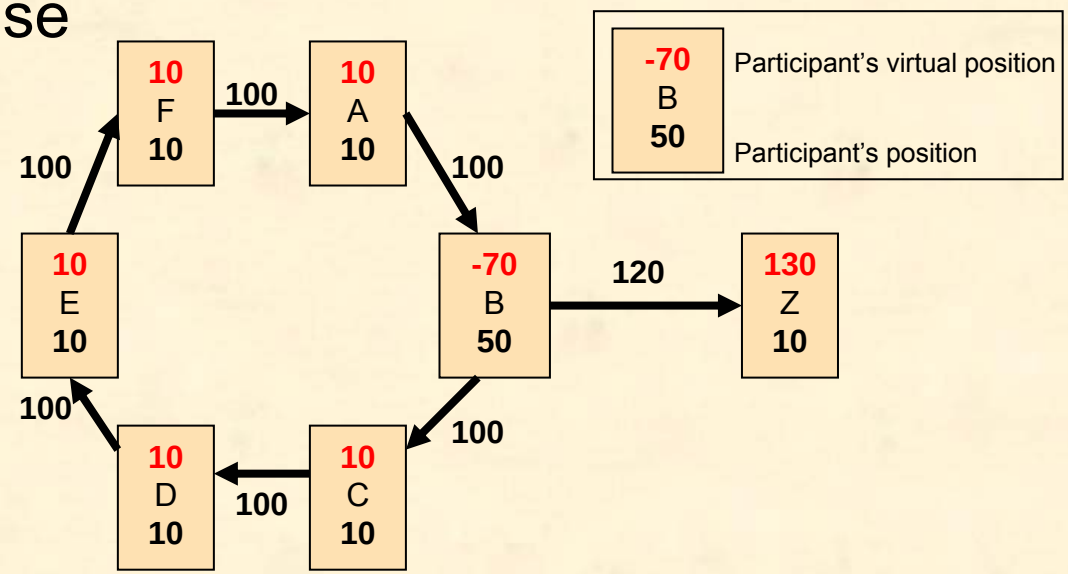
- If it exists, inactivate the smallest payment whose value is higher than the deficit.
- Otherwise inactivate the payment with the highest value.

T2

- Inactivate the most recent payment from this participant.

Multilateral optimization
Standard offsetting algorithms

- Test case



- PNS: The payment of value 100 (the smallest whose value is higher than the deficit 70) is unselected. Failure
- TARGET2: The most recent payment is unselected.

Multilateral optimization
Advanced non-FIFO offsetting algorithms

- Some ideas to improve on the current PNS algorithm
- Favour liquidity transfers towards the center by removing peripherical participants
- Multilateral PNS Las Vegas
  - Same in construction as PNS
  - Starting participant in deficit chosen randomly
  - Payment inactivated chosen randomly (using appropriate probabilities)
- Multilateral Greedy Las Vegas
  - Starting participant in deficit chosen randomly
  - All payments from the considered participant unselected and considered for re-selection in the decreasing order of their value (using appropriate probabilities)

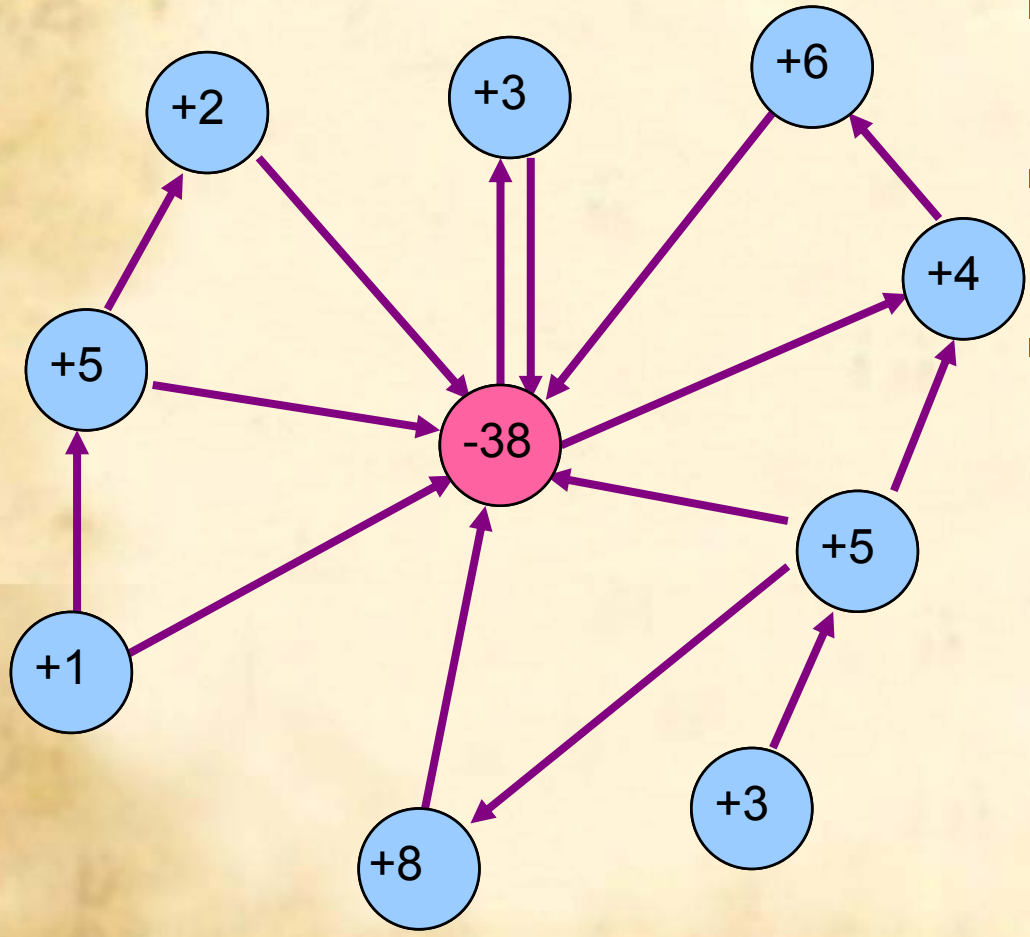
Multilateral optimization
Advanced non-FIFO offsetting algorithms

- OPM 10-10
  - Choose a bank with a negative virtual position
  - For each of the outgoing payments of this bank calculate a coefficient depending on:
    - How close the payment is to the deficit of the bank
    - Whether unselecting the payment makes the bank's virtual position positive
    - Whether unselecting the payment creates or amplifies another bank's deficit
  - The payment with the highest coefficient is unselected

Settlement of an urgent AS during a crisis. Scenario

- Settlement of AS after an operational problem.
- Zero liquidity in the system (pre-disaster positions not accessible, f.ex Regional disaster in T2).
- 1 highly urgent ancillary system (“all or nothing”, 10 participants) waiting to be settled...
- A certain number of lower importance payments between the AS participants (generated randomly according to a log-normal law $m=4.4$, $\sigma=1.6$)
- Aim: reduce the liquidity needs of the AS participants in a net debit position.

Settlement of an urgent AS during a crisis. Scenario

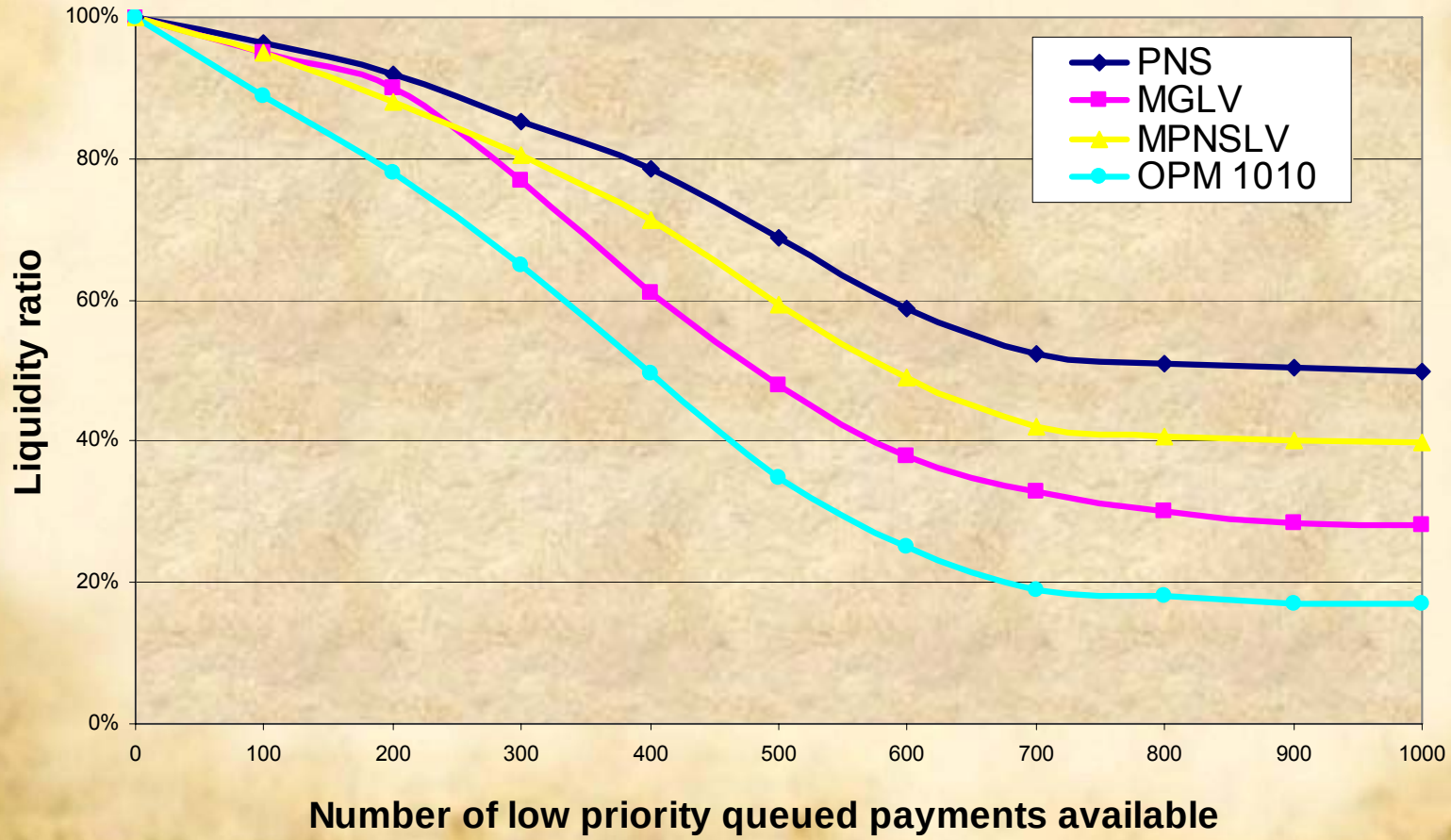


- 9 participants with an AS position of +11M
- 1 participant with an AS position of -100M
- Let the multilateral optimisation algorithm select some of the N queued payments in order to reduce the liquidity needs of the participant in a net debit position
- Here liquidity ratio=38%

Settlement of an urgent AS during a crisis. Results

Liquidity ratio vs algorithm and number of low priority payments available

Average over 100 randomly generated distributions

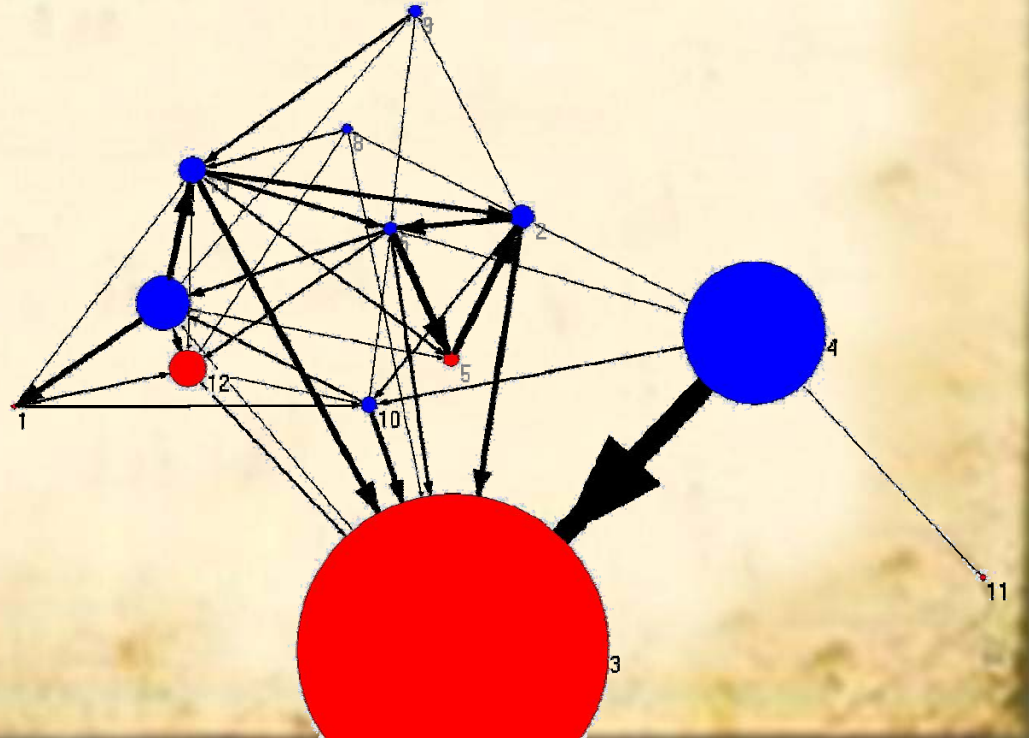


Mitigating the consequences of a technical default in the French LVPS PNS

PNS

- Privately owned large value payment system
- March 2006:
  - 17 participants
  - Between €45 and €90 billions settled per day
  - Around 20 000 payments per day
- Real-time gross system with bilateral limits and optimization algorithms

PNS structure



Mitigating the consequences of a technical default in the French LVPS PNS

Principle

- The biggest participant faces operational problems
  - It is unable to send payments…
  - But it still receives payments from the other participants
  - And thus turns into a “liquidity trap”
- Simulations
  - Real data used
  - BdF’s simulator reproduces exactly the behavior of PNS (data, entry mechanism, optimization algorithms…)
- Measured consequences of the technical default…
  - Increase in settlement delay
  - Rejected payments at the end of the day

Mitigating the consequences of a technical default in the French LVPS PNS

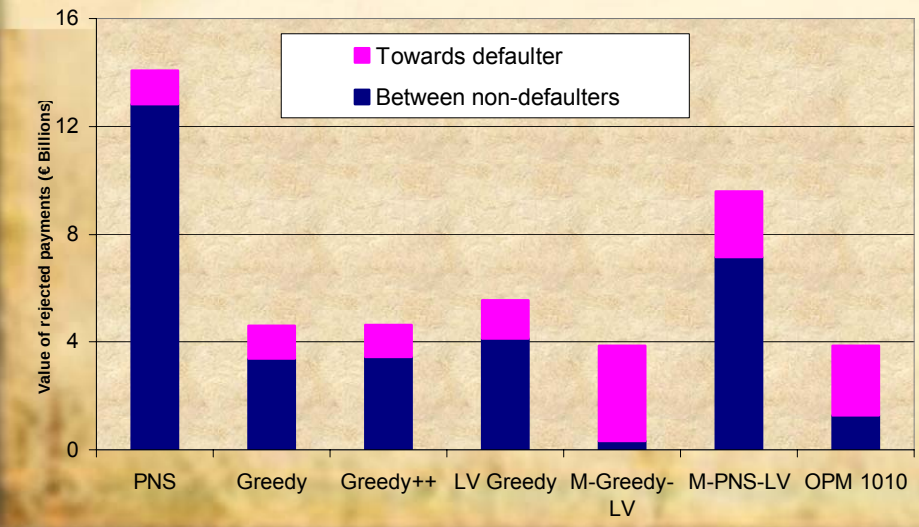
Advanced algorithms in the case of a default

- Simulations were made to assess the impact of advanced offsetting algorithms on the system, in case of the technical default of the biggest participant (17 march 2006)
  - Normal PNS
  - PNS' FIFO bilateral optimization replaced by Greedy
  - PNS' FIFO bilateral optimization replaced by Greedy++
  - PNS' FIFO bilateral optimization replaced by Las Vegas Greedy
  - PNS' multilateral optimization replaced by M-Greedy-LV
  - PNS' multilateral optimization replaced by M-PNS-LV
  - PNS' multilateral optimization replaced by OPM 10-10

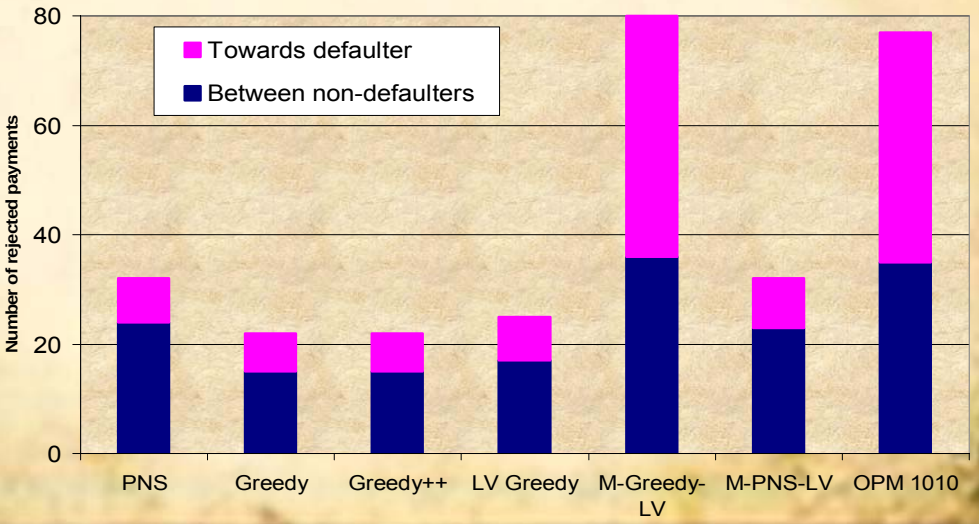
Mitigating the consequences of a technical default in the French LVPS PNS

- Results
- 17 March, technical default of the biggest participant
- Various algorithms in replacement of PNS'
  - Bilateral (Las Vegas: stop after 5 unsucessful tries in a row)
  - Multilateral (Las Vegas: stop after 5 unsucessful tries in a row)

Rejected payments (value)



Rejected payments (volume)



Mitigating the consequences of a technical default in the French LVPS PNS

- Results
- 17 March, technical default of the biggest participant
- Various algorithms in replacement of PNS'
  - Bilateral (Las Vegas: stop after 5 unsucessful tries in a row)
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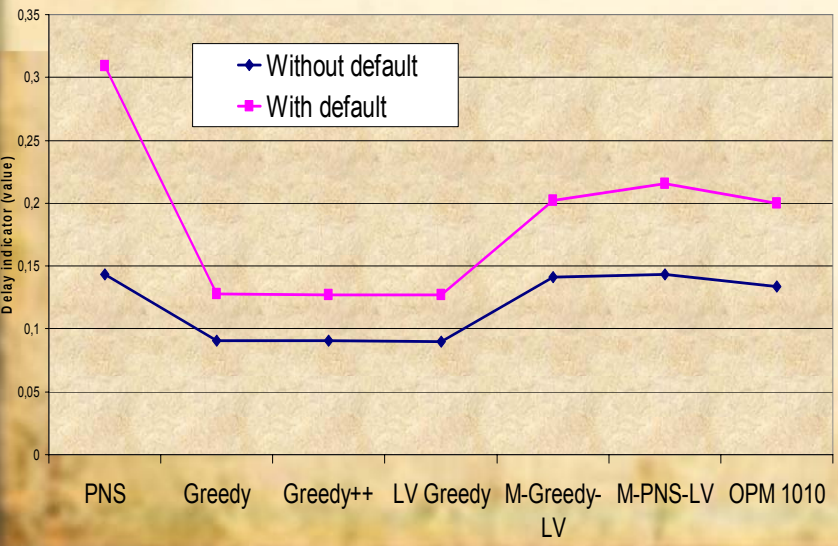
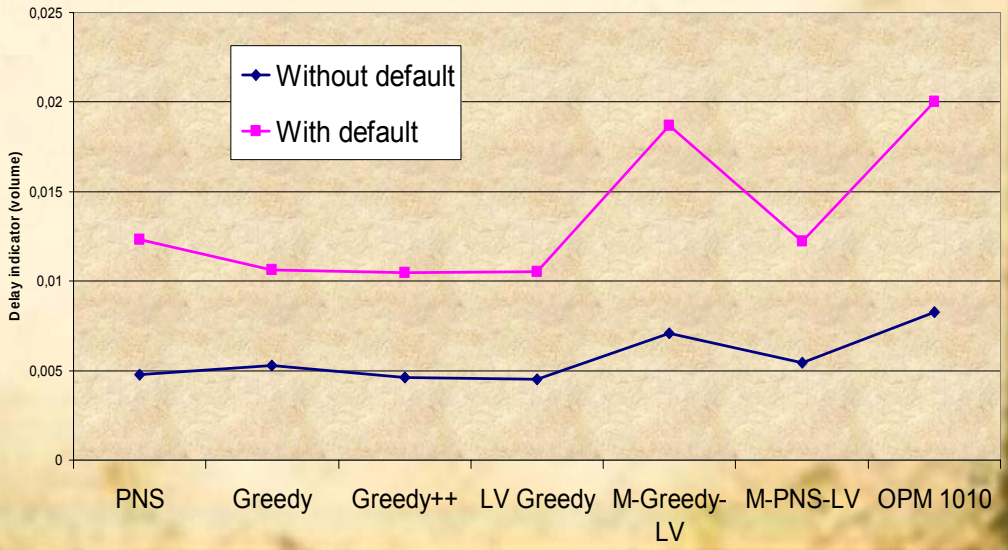
Delay indicator (value)



Delay indicator (volume)



Mitigating the consequences of a technical default in the French LVPS PNS

Insight providing example

- Technical default of the biggest participant 17/03/2006
- Focus on the bilateral relation between 2 participants

- Payments rejected at the end of the day by PNS
- Payments settled with Greedy++
- Payments settled with Greedy

	A	B
Cash position €	3.5 M	22.5 M
Queued payments between A and B	160 M	1 000 M
	313 M	3 500 M
	956 M	87 M
	1 500 M	
	2 000 M	
	51 M	
	180 M	

Mitigating the consequences of a technical default in the French LVPS PNS

Conclusion

- Optimization algorithms can in some cases:
  - Lower the settlement delay
  - Lower the value of the rejected payments
- Two different approaches
  - Non-Fifo algorithms in replacement
  - Non-Fifo algorithms only as a final optimization before rejection
- However this effect is very case-dependent
  - Sometimes the final optimization brings nothing, as PNS algorithms have already settled many payments (2 cases out of 6)

General conclusion

- Today: liquidity rich systems
  - Free providing of intraday liquidity against collateral
  - No need for more advanced algorithms in normal operation (although increase in settlement speed non negligible)
- Under special circumstances
  - Technical default / Liquidity crisis
  - Can help mitigate the consequences
    - Settle a highly urgent AS faster
    - Lower the number of rejected payments during a crisis
- Calculation time
  - Greedy faster than PNS, OPM 10-10 not significantly slower, LV 3 times slower
- Non-Fifo advanced algorithms
  - Could be useful in some circumstances
  - Still a lot of room for improvements

References

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- *An optimization algorithm for the clearing of interbank payments.* Shafransky, Y., Doudkin, A., European Journal of Operational Research, (2006) 743-749

- *Analysis, by simulation, of the impact of a technical default of a payment system participant. An illustration with the PNS system.* E. Mazars, G. Woelfel. Liquidity, risks and speed in payment and settlement systems – a simulation approach (2005), Bank of Finland

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