Coordinated Multi-Lateral Trades for Electric Power Networks:
Theory and Implement

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Outline

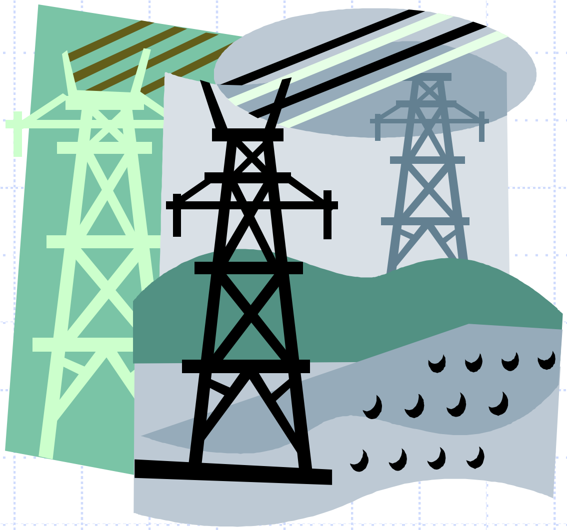
- Background and Motivation
- Coordinated Multi-Lateral Trades
- An Example (3-Bus Scenario)
- Conclusion and Discussion

Changes in Power Networks

- Increase competition;
- Enhance consumer choice;
- Properly arrange access to transmission services.

Two Schemes to Reconstruct Transmission System?

- Bilateral Model
- Poolco Model



Bilateral Model

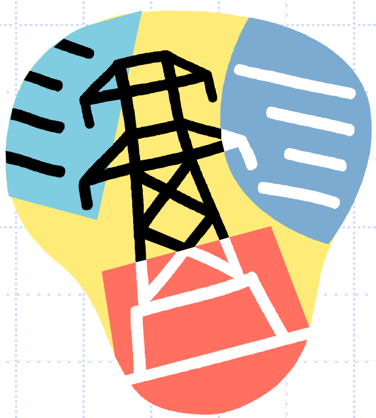
Suppliers and consumers independently arrange trades

- Setting by themselves the amount of generation and consumption
- Setting by themselves the corresponding financial terms.

Disadvantage

- Lack of Coordination.

Need Power System Operator!



Poolco Model

Suppliers and consumers

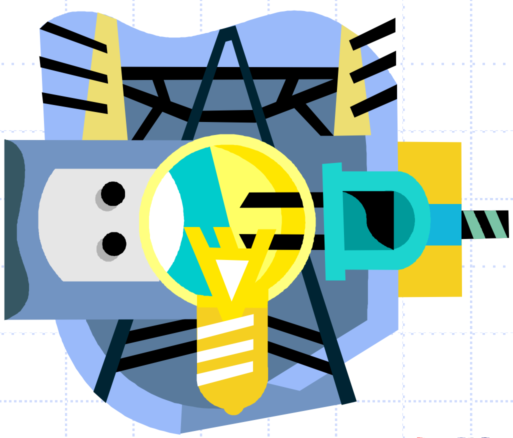
- offer price and quantity bids to poolco for traditional bundled services.

Pool System Operator

- determines which trades to accept and execute
- sets the price at which trades are settled

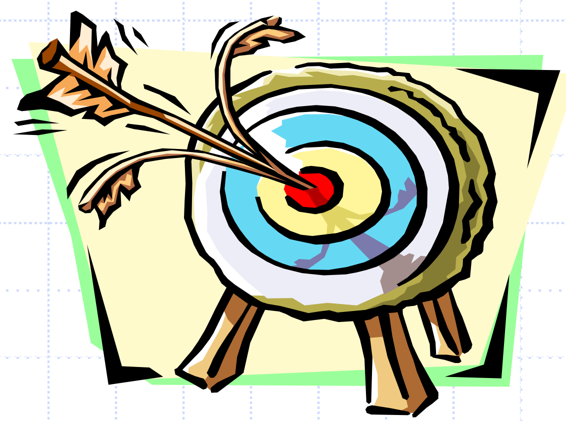
Disadvantage

- Poolco is a monopolist.



Goals

To develop a new operating paradigm that is compatible with the competitive market structure.



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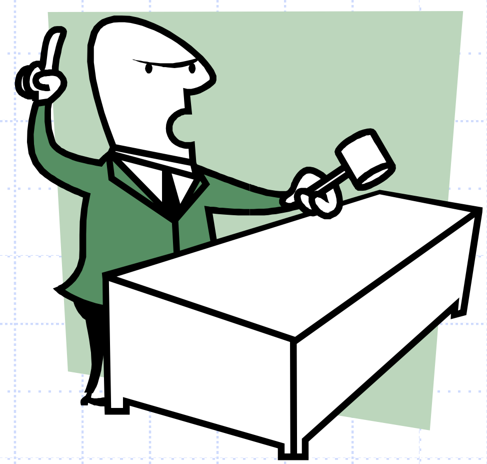
Power System Operation

Three Main Operating Objectives

- Power Balance
- Security/Reliability
- Economy



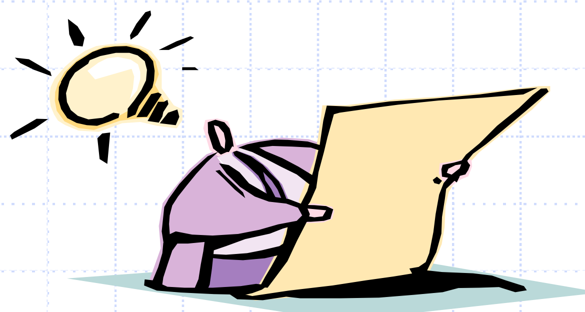
Requirements

- Coordination among all parties
- Security & Economy
- Scheduled & Real-Time Power Balance

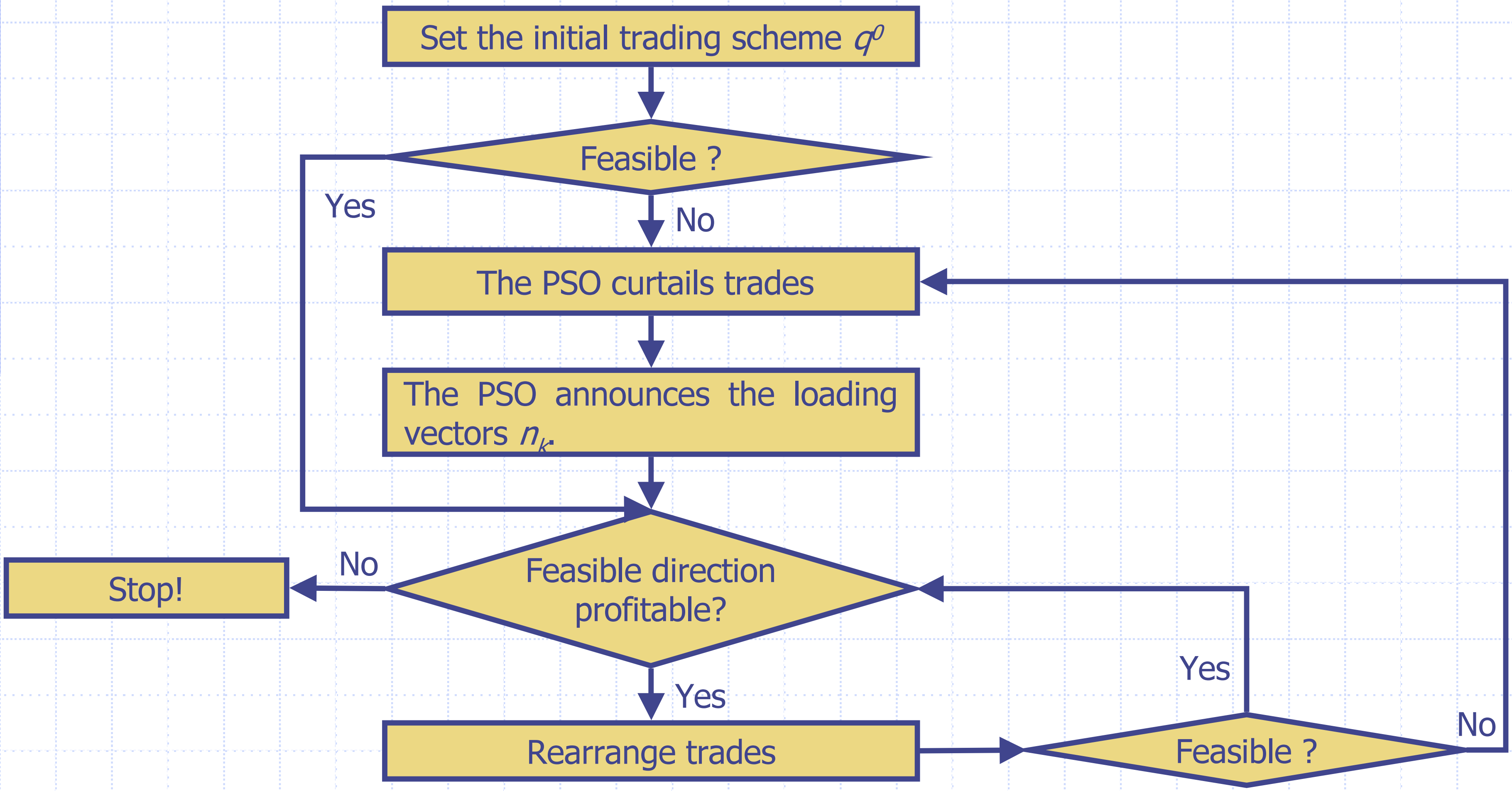
Coordinated Multi-Lateral Trading

Basic Idea

- Suppliers and Consumers seek profit on their own.
- Power System Operator (PSO) guarantees security.

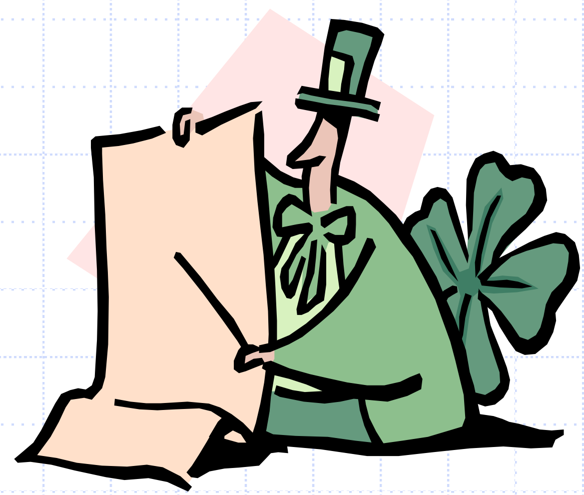


Coordinated Multi-Lateral Trading



Coordinated Multi-Lateral Trading

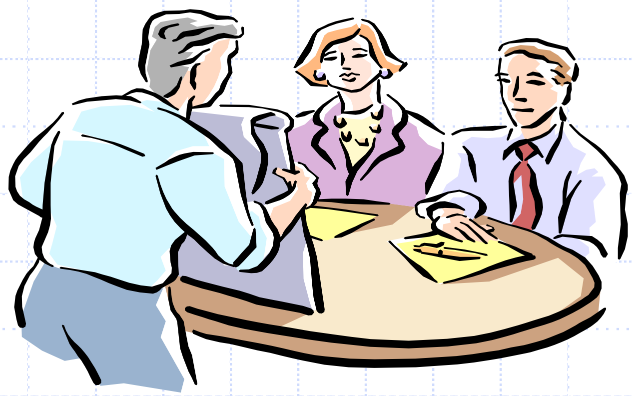
- Loss-Included Trades
- Feasible Trades
- Trading Arrangements



Loss-Included Trades

How to allocate total losses to individual trades?

- The PSO calculates and broadcasts a quadratic loss matrix.
- The brokers estimate their shares according to that matrix.



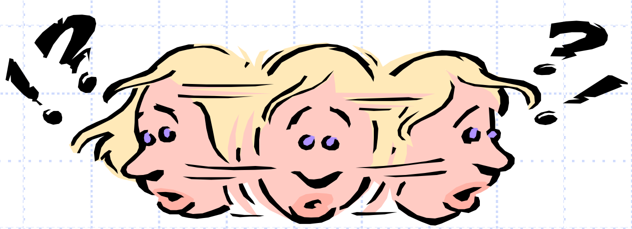
Feasible Trades

How to find feasible & profitable trades?

- The PSO calculates the loading vector and broadcasts this set of numbers to everyone.
- Based on the loading vector, brokers privately arrange profitable trades that are feasible.

Trading Arrangements

- How many parties need to be involved in the trade?
- Who should be contacted for negotiation?
- What is the optimal level of generation (or consumption) for each party in the trade?



Implementation Requirements

- Scheduled vs. Real-Time Markets
- Computation Requirements
- Communications Requirements
- Data Requirements
- Organizational Requirements

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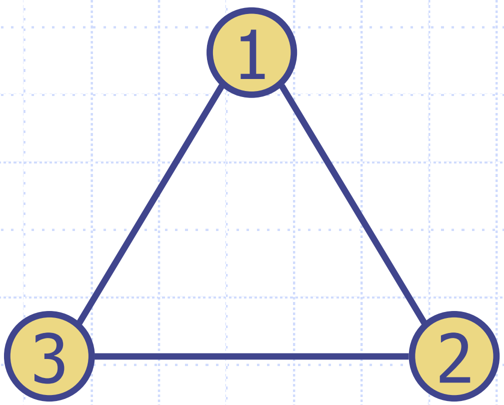
An Example (3-Bus Scenario)
-- System Parameters



	r	x
1-2	0.0600	0.4000
2-3	0.0315	0.2500
3-1	0.0400	0.2000

Cost Functions ($/hr)

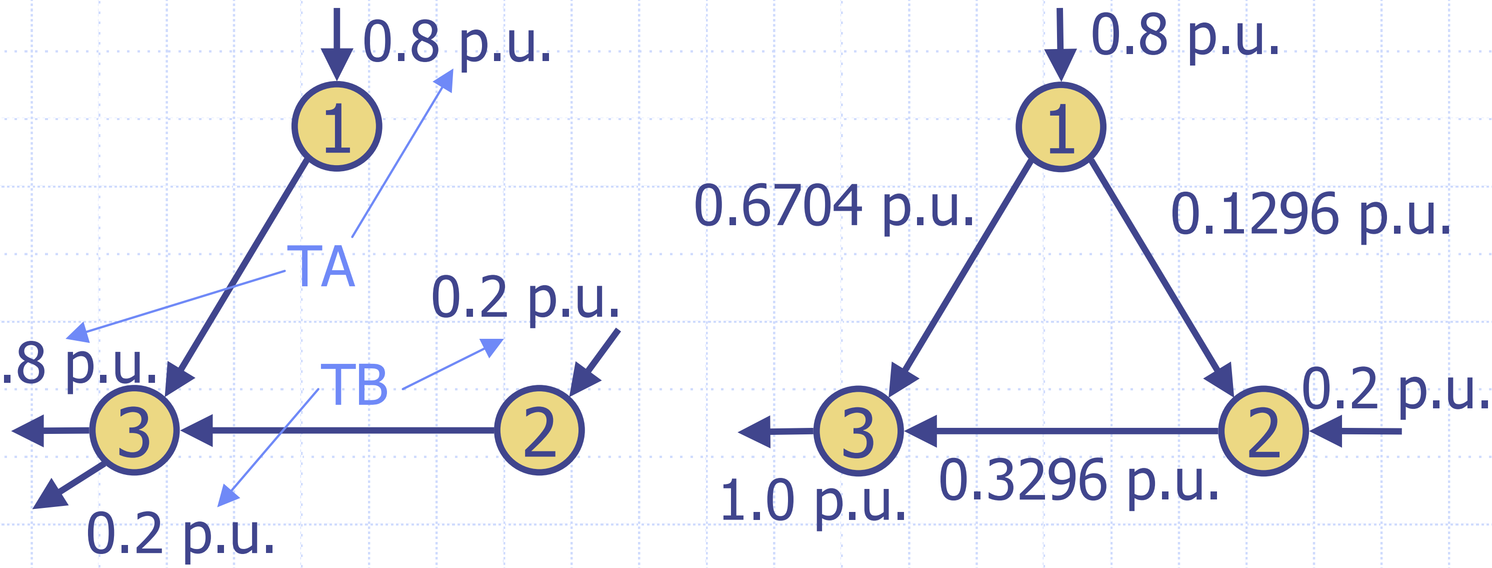
$$c_1(q_1) = 6480q_1 + 128q_1^2$$

$$c_2(q_2) = 6620.8q_2 + 160q_2^2$$

$$c_3(q_3) = 6684.8q_3$$

Per Unit: 1 p.u. = 100 MW

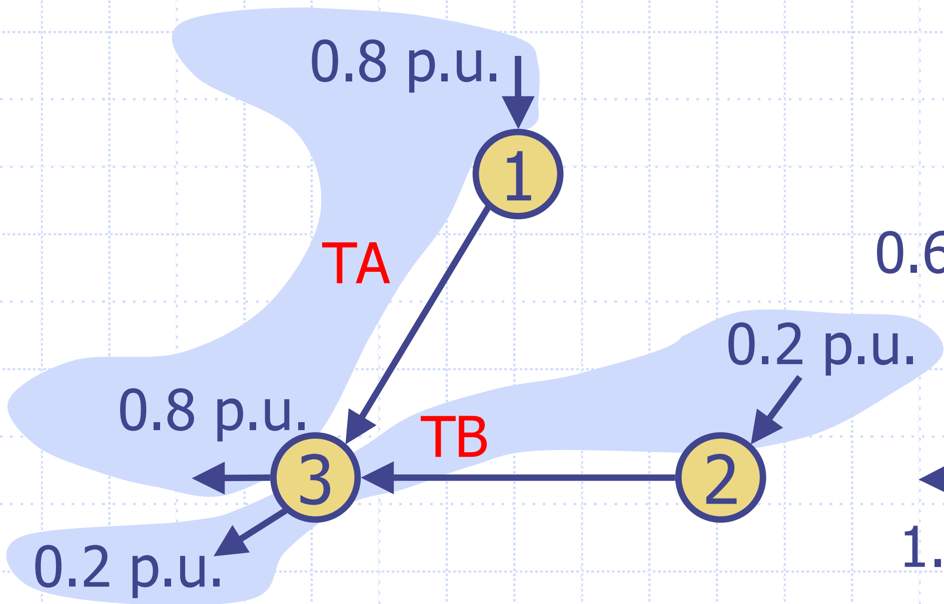
An Example (3-Bus Scenario)
-- Initial Trades



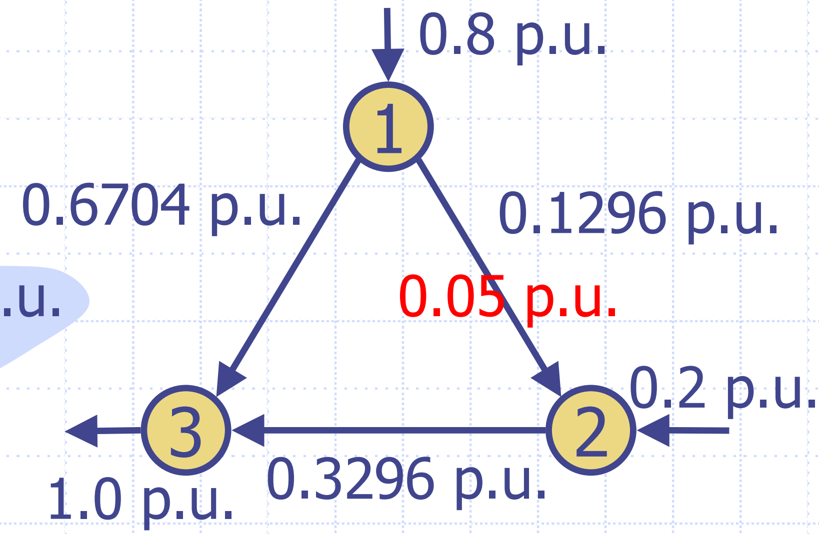
Contract Flows   Power Flows

Marginal Costs (MC) $\left.\frac{c_i}{p_i}\right|_{\text{Operating Point}}$ $MC_1=MC_2=MC_3=6.6848$

An Example (3-Bus Scenario)
-- Initial Trades



Contract Flows



Power Flows

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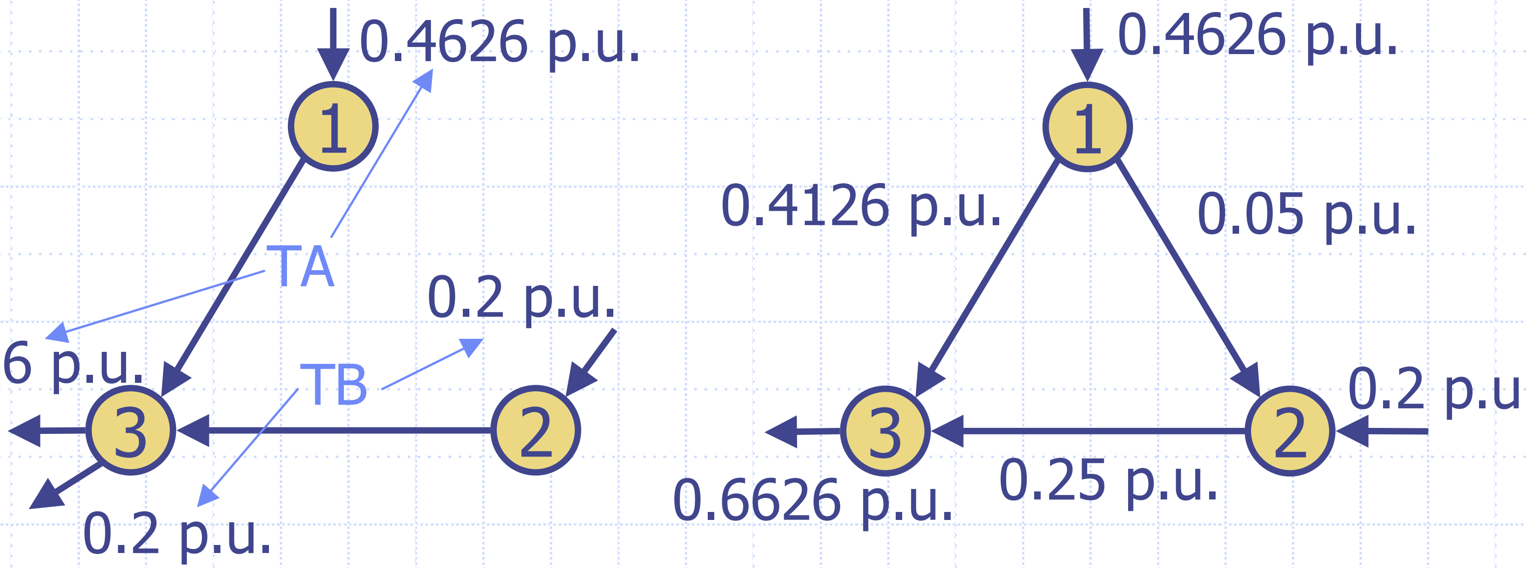
An Example (3-Bus Scenario)
-- Curtailed Trades



Contract Flows   Power Flows

Marginal Costs (MC) MC_1=6.5984, MC_2=6.6848, MC_3=6.6848

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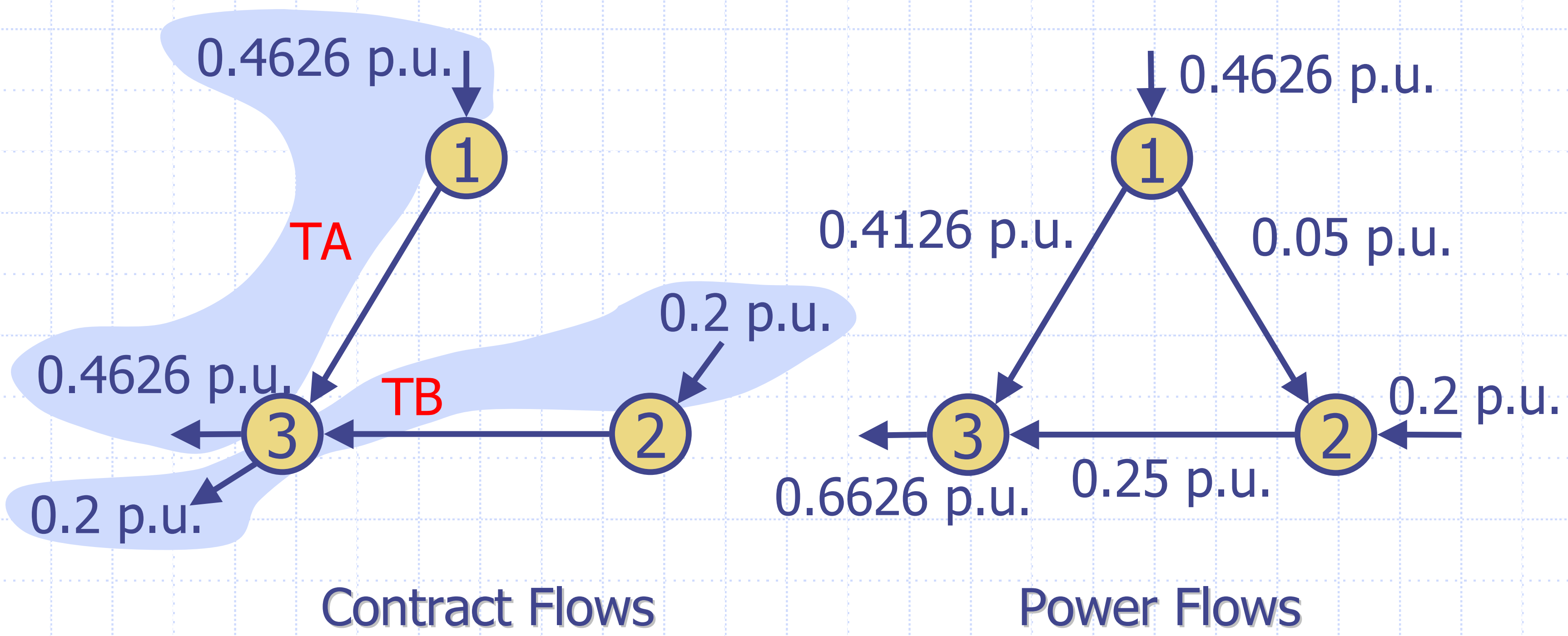

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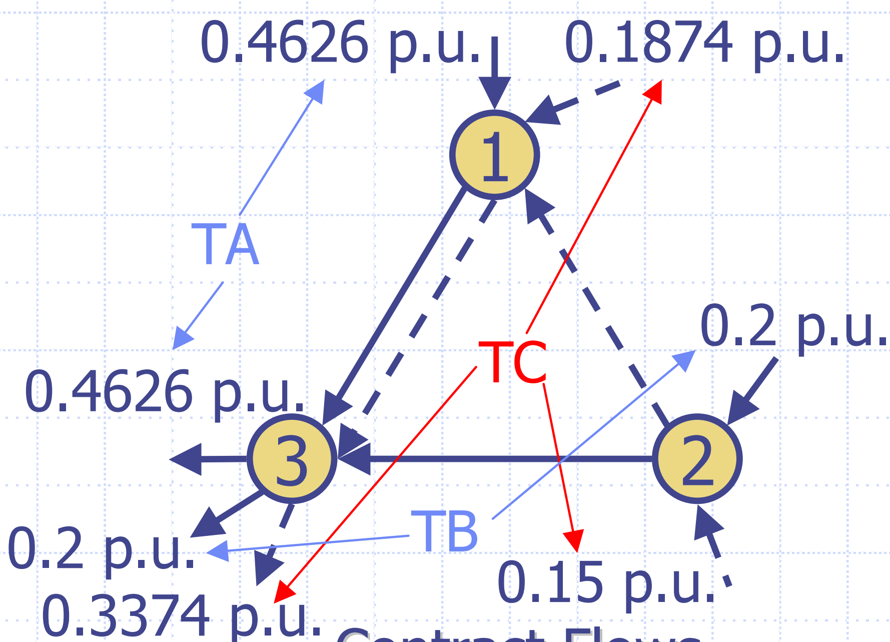
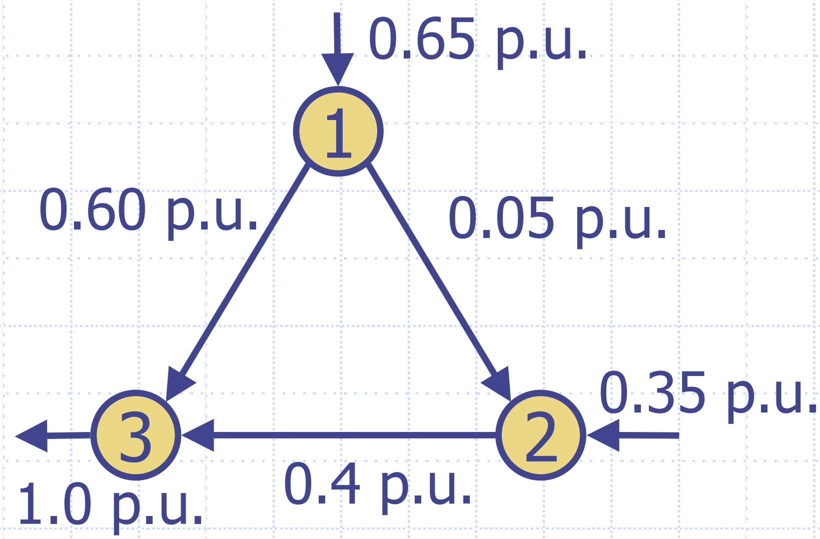
An Example (3-Bus Scenario)
-- Additional Trade



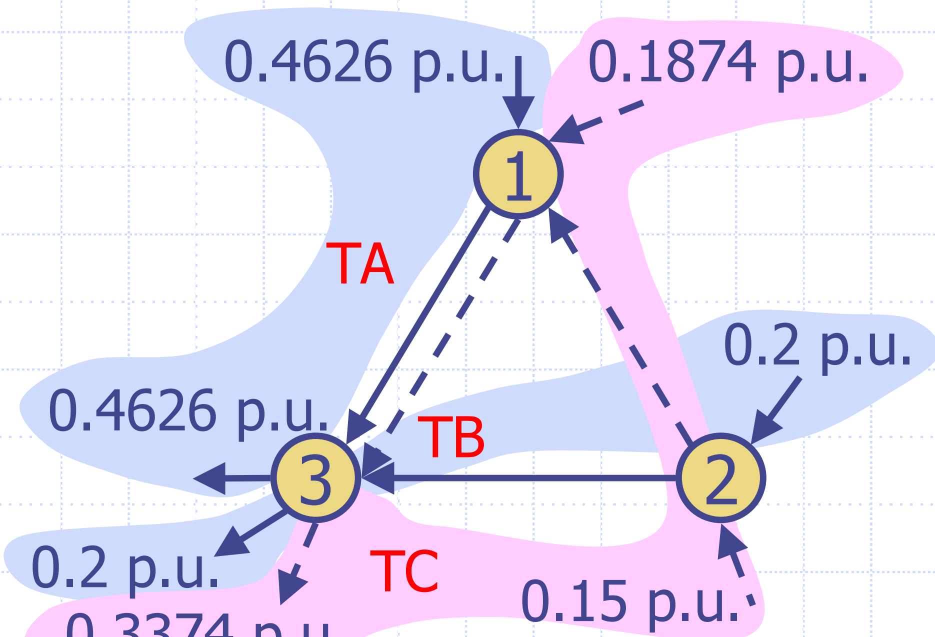
Contract Flows



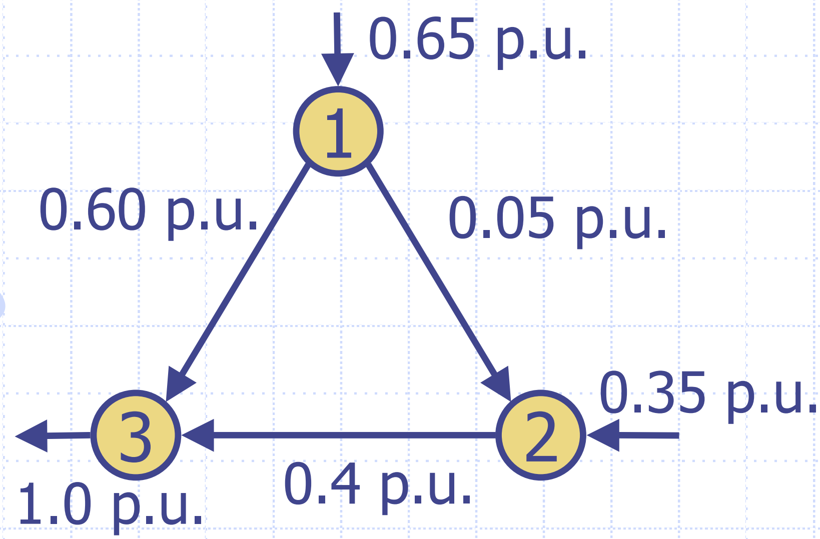
Power Flows

Marginal Costs (MC) MC_1=6.6464, MC_2=6.7328, MC_3=6.6848

An Example (3-Bus Scenario)
-- Additional Trade



Contract Flows



Power Flows

Marginal Costs (MC) MC_1=6.6464, MC_2=6.7328, MC_3=6.6848

An Example (3-Bus Scenario)
-- Loss Allocation

Estimated Loss Component (MW)

	TA	TB	TC	Total
TA	0.63	0.096	0.33	1.05
TB	0.096	0.099	0.11	0.31
TC	0.33	0.11	0.22	0.66
Total				2.02

Components of Transmission Losses (MW)

	TA	TB	TC	Total
TA	0.62	0.094	0.32	1.03
TB	0.094	0.097	0.11	0.30
TC	0.32	0.11	0.21	0.65
Total				1.98

An Example (3-Bus Scenario)
-- Loss Allocation

Estimated Losses (MW)

Trading	TA	TB	TC	Total
Est Losses	1.04	0.31	0.65	2.00

Loss Allocation (MW)

Trading	TA	TB	TC	Total
Loss Alloc	1.03	0.30	0.65	1.98

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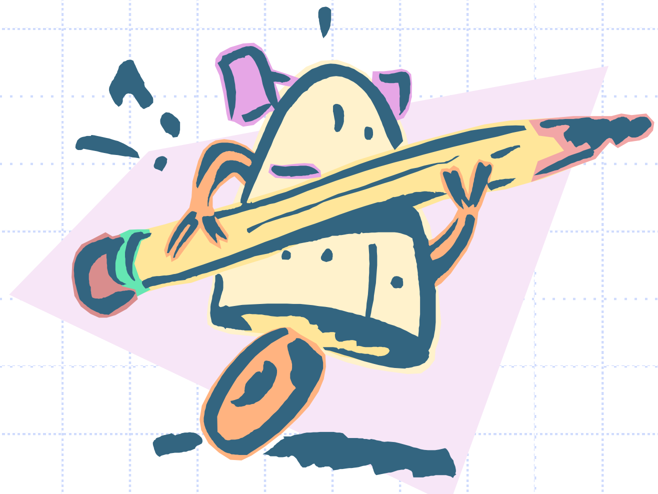
Conclusion

- This model achieves short term efficiency!
- This scheme can be achieve by today's techniques



Is PSO Necessary?

? Transmission Constraints

? Loading Vector & Quadratic Loss Matrix