On Some Optimization Problems

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Outline

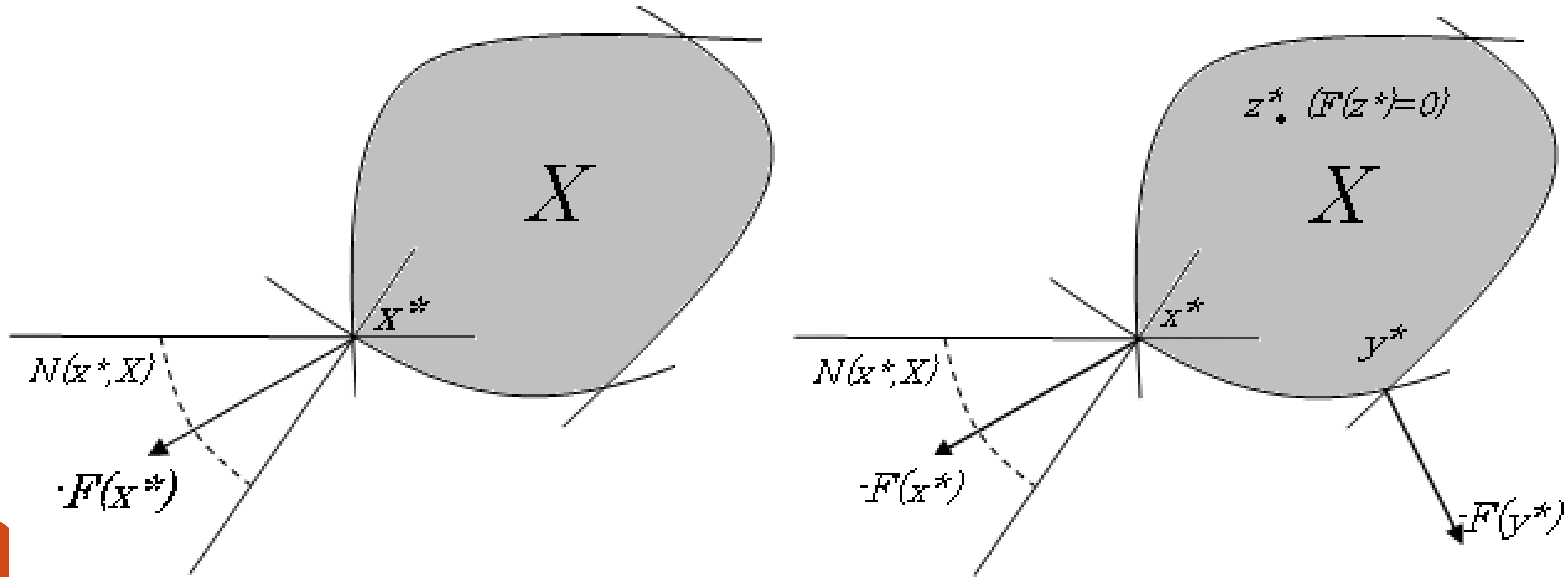
- **Research background**
  - Optimization
- **Research in Staffordshire University**
  - Mathematical modeling for ore processing in copper mining industry
- **Research in University of Joseph Fourier**
  - Mathematical modeling for itinerary planning

Variational Inequality Problem

For a given nonempty closed convex set $S \subseteq \Re^n$ and a continuous mapping $F : \Re^n \to \Re^n$, the *variational inequality problem*, denoted VI(S, F), is to find a vector $x^* \in S$ such that

$$\langle F(x^*), x - x^* \rangle \geq 0, \quad \forall x \in S, \tag{1}$$

where $\langle \cdot, \cdot \rangle$ denotes the inner product in $\Re^n$.



VIP – Applications

- when $S \equiv \Re^n$, (1) $\Longleftrightarrow$

$$F(x) = 0. \qquad (2)$$

- when $F(x) \equiv \nabla f(x)$, (1) $\Longleftrightarrow$ the optimality condition for

$$\min f(x) \text{ subject to } x \in S. \qquad (3)$$

- Saddle point problems
- Nash equilibrium, Economic equilibrium and Traffic equilibrium problems
- Nonlinear obstacle problems
- Pricing American options
- SPSD matrices optimization
- …

VIP – Solution methods

Methods for monotone VIPs

- projection methods, proximal point methods, splitting methods, equation reduction and interior point methods, …

Methods for not necessarily monotone VIPs

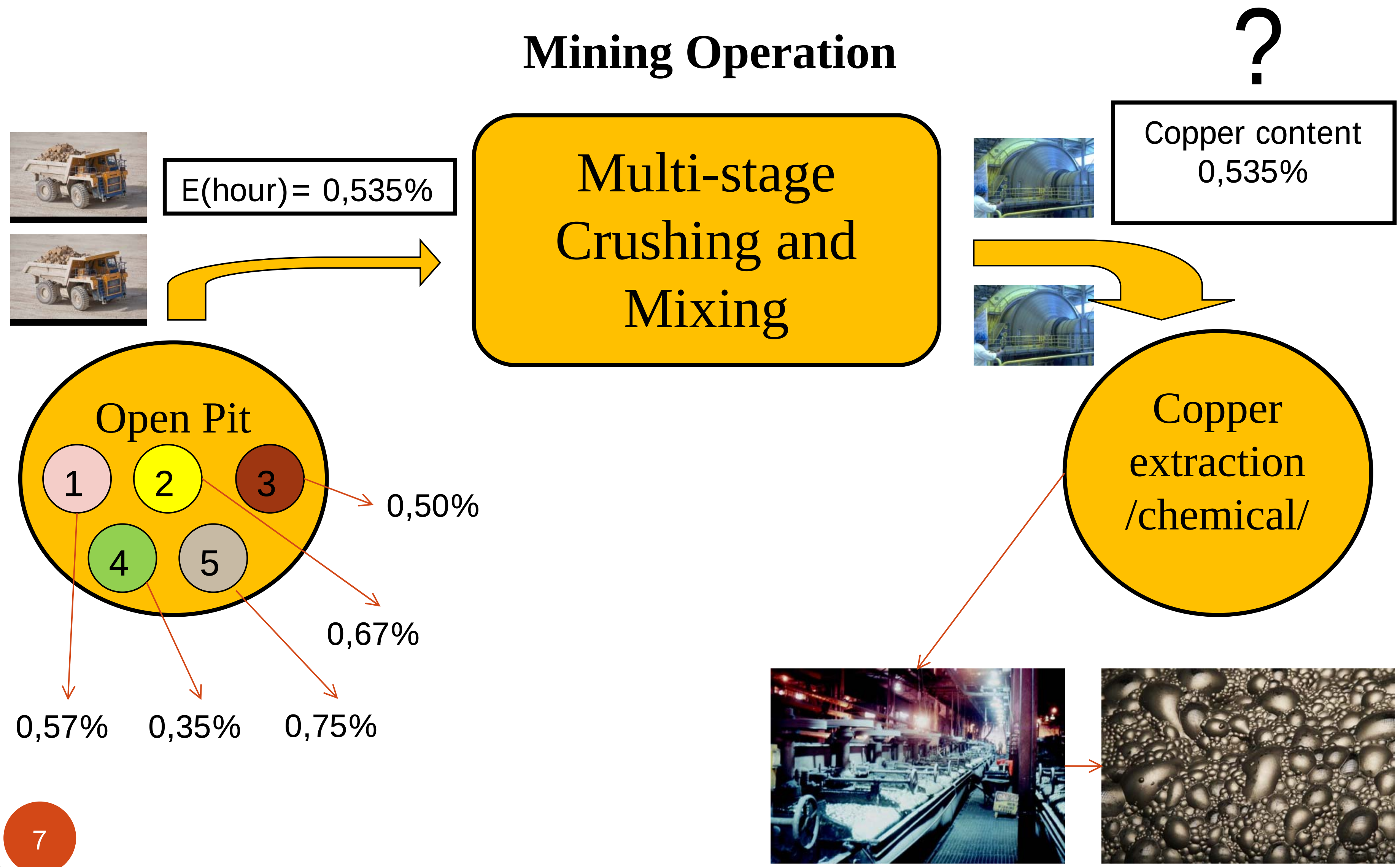
- KKT based methods
- merit function based methods
  - Lipschitzian branch and bound method
- restricted step Josephy-Newton method
- hybrid evolutionary algorithm
  - (global optimization algorithm)
  - (generalized Nash equilibrium algorithm)

Erdenet Copper Mining Factory

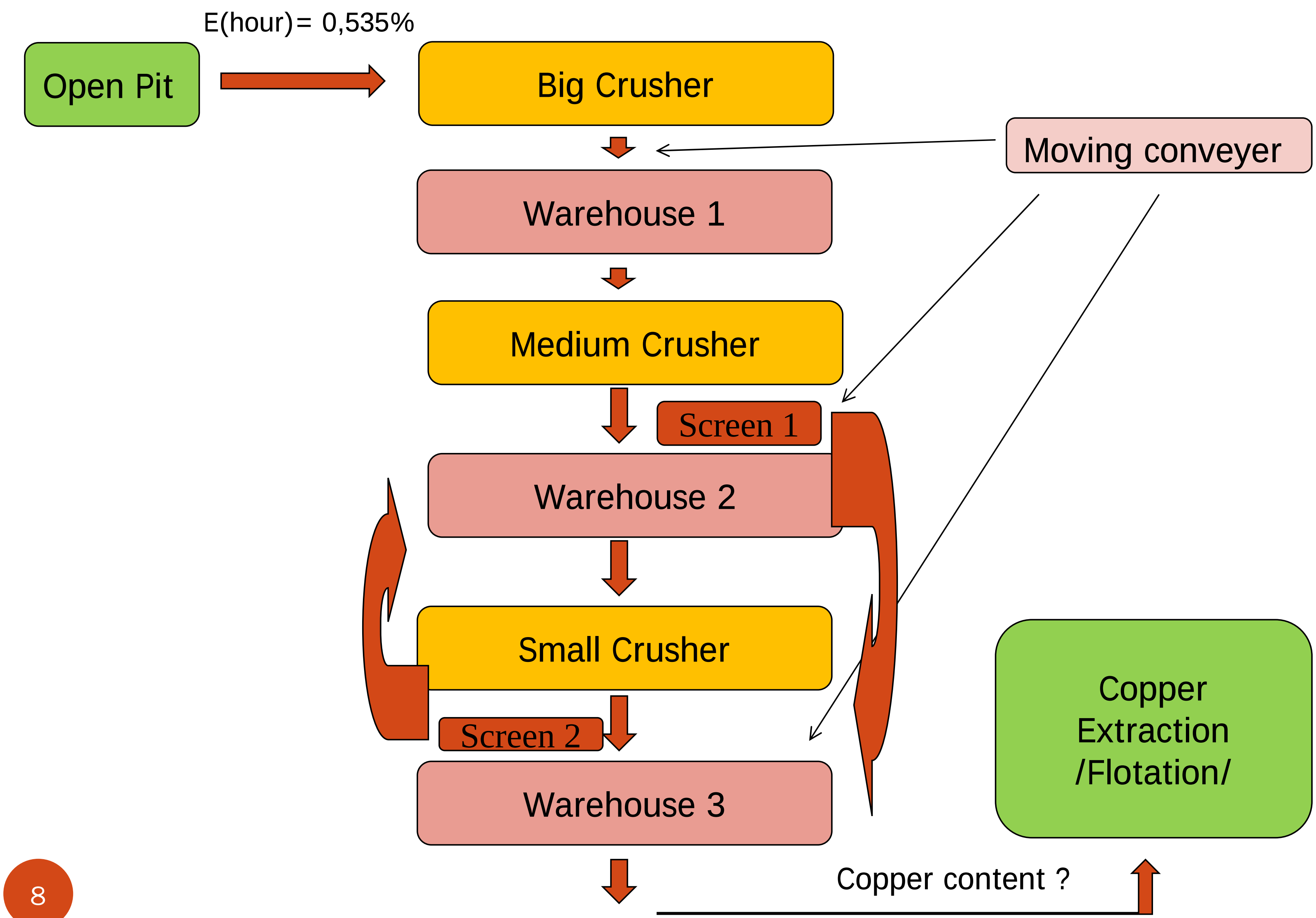
- started its operation in 1978
- Erdenet processes 25 million tons of ore in a year
- another 30 years of resource is left

- produces 126.700 tons of copper and 1954 tons of molybdenum /2010/
- accounts for 13.5% of GDP
- produces 1% of world copper industry

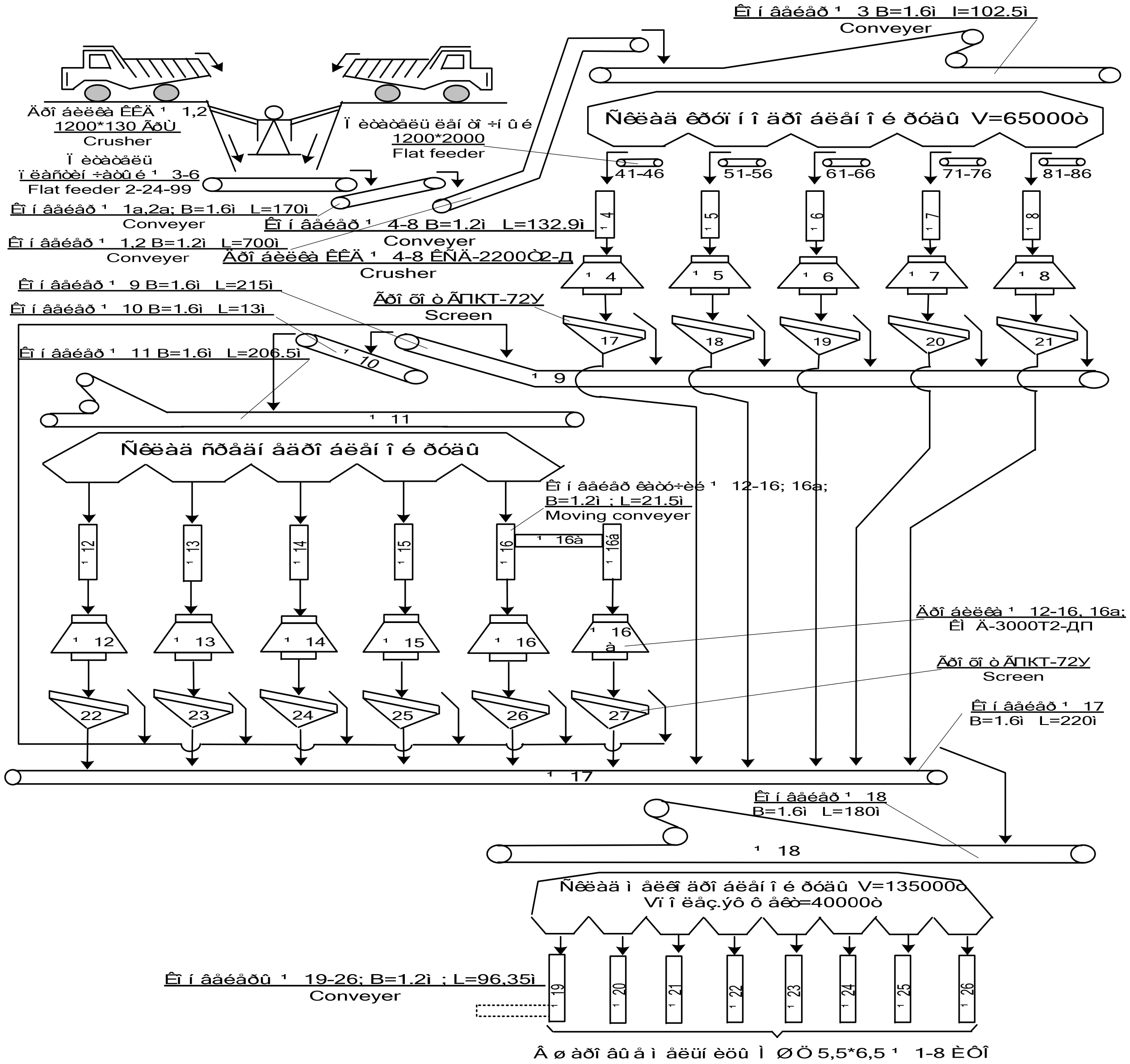
Copper ore processing



Ore crushing and mixing procedure



Ore crushing and mixing procedure

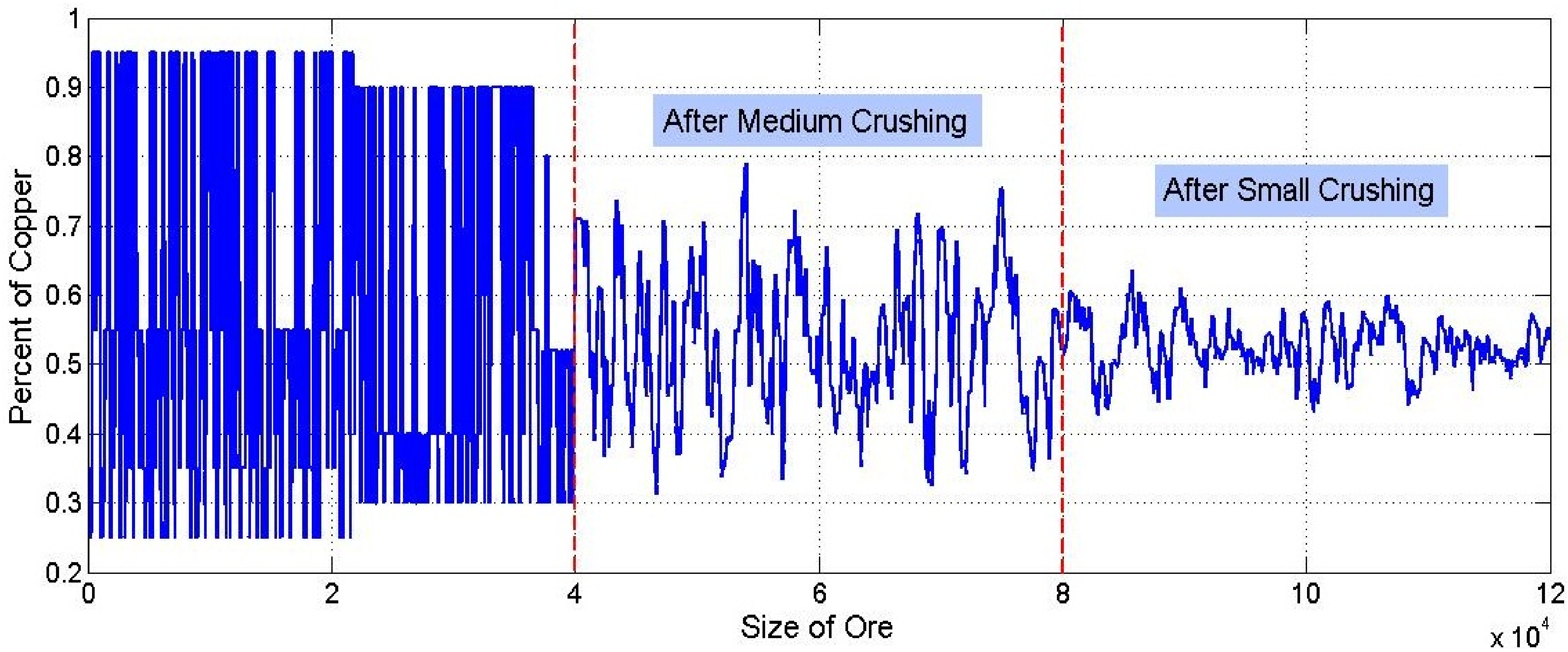


Ore crushing and mixing procedure

Our goal and approach

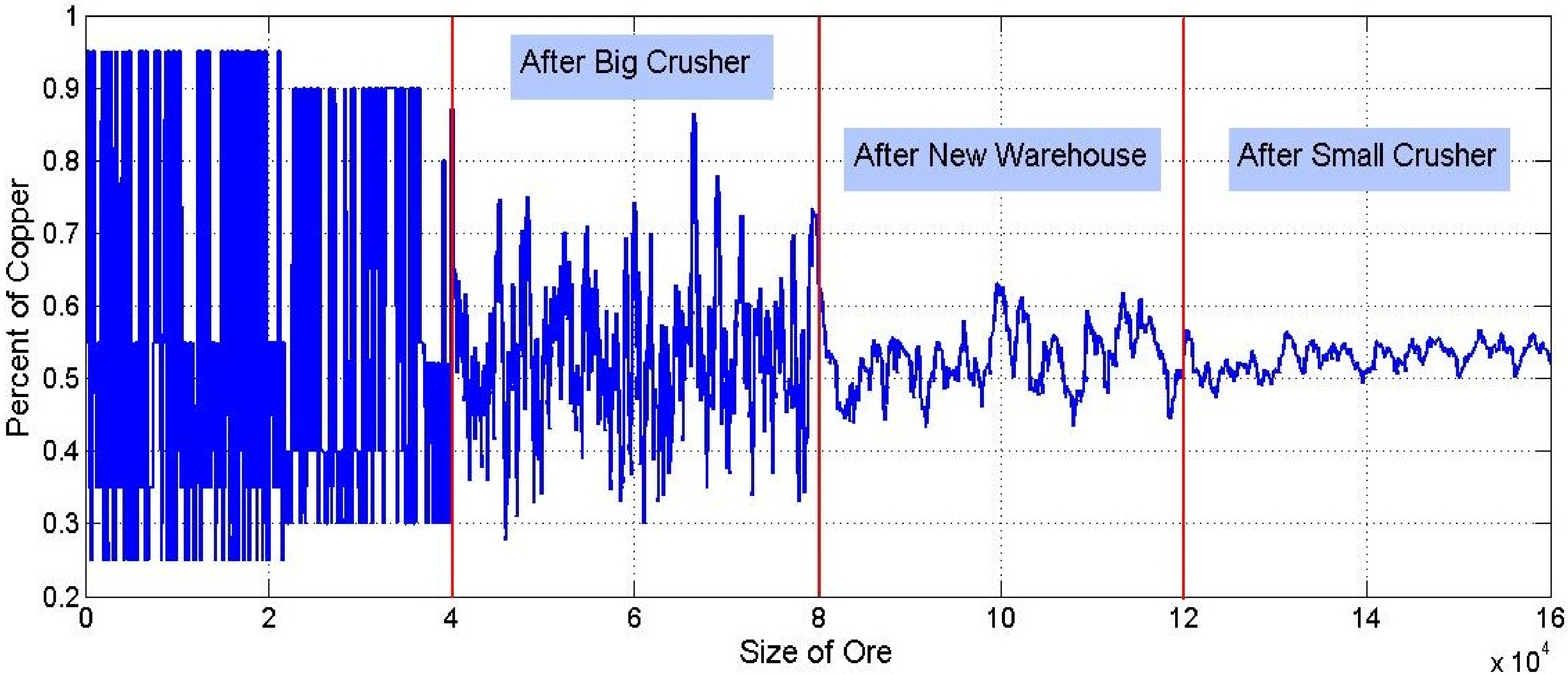
- To construct some mathematical model for the ore crushing and mixing process
- To conduct numerical and simulation analysis for the model
- To analyze different ways to conduct the ore crushing and mixing process

Simulation analysis



46.6% of output ore has copper content in the interval 0.535±5%

Building another warehouse



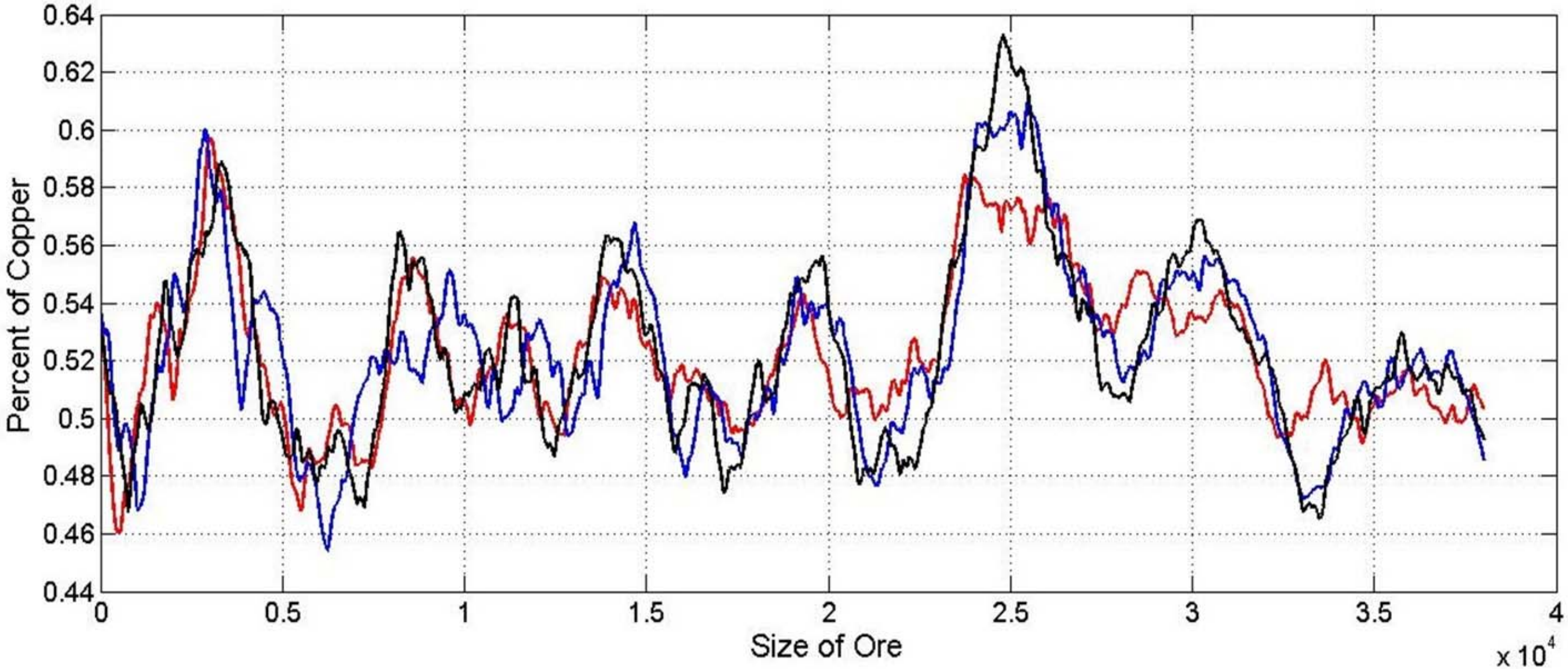
83.6% of output ore has copper content in the interval 0.535±5%

Increasing mixture: comparison

	Procedure	Ore with copper content in the interval 0.535±5%
1	Current	46.6%
2	Continuous movement of warehouse conveyor	45.7%
3	Two trucks at a time in Big crusher	61.7%
4	Using 20 tons trucks	52.2%
5	Building another warehouse	83.6%

Possibility of predicting the output

Constant and continuos movement of warehouse conveyors



Itinerary planning problem

A tourist is coming to a city (Paris). The city has attraction points of number *n,* and the tourist has some amount of money (M) to spend on sightseeing under the time period of T. Determine the best route for the tourist concerning the expected satisfaction to be maximal?

Complexity

- If n=10, there are 3628800 different routes.
- If the tourist were to choose 7 places out of ten, there are 5040 different routes.

Mathematical modeling

Input

Places of Interest	Cost	Time	Expected satisfaction
A1 (Eiffel Tower)	C1	T1	S1
A2 (Notre Dame)	C2	T2	S2
…	…	…	…
An (Disneyland)	Cn	Tn	Sn

Mathematical modeling

Transportation cost and time matrices

$$
\begin{pmatrix}
0 \; c_{12} \; c_{13} \cdots c_{1n} \\
c_{12} \; 0 \; c_{23} \cdots c_{2n} \\
\cdots \\
\vdots \\
c_{1n} \; c_{2n} \cdots \cdots 0
\end{pmatrix}
\qquad
\begin{pmatrix}
0 \; t_{12} \; t_{13} \cdots t_{1n} \\
t_{12} \; 0 \; t_{23} \cdots t_{2n} \\
\cdots \\
\vdots \\
t_{1n} \; t_{2n} \cdots \cdots 0
\end{pmatrix}
$$

Optimization model

Sum(satisfaction) ---- > maximize

Sum(sightseeing time) + Sum(trans. time) <= Time
Sum(sightseeing cost) + Sum(trans. cost) <= Cost

Mathematical modeling

Complexity

- Scheduling
- Constraint satisfaction problem
- Assignment problem

Approaches for the solution

- Deterministic (problem specific algorithm)
- Genetic algorithm
- Simulation based optimization

Thank you for your attention!

Questions & Comments?