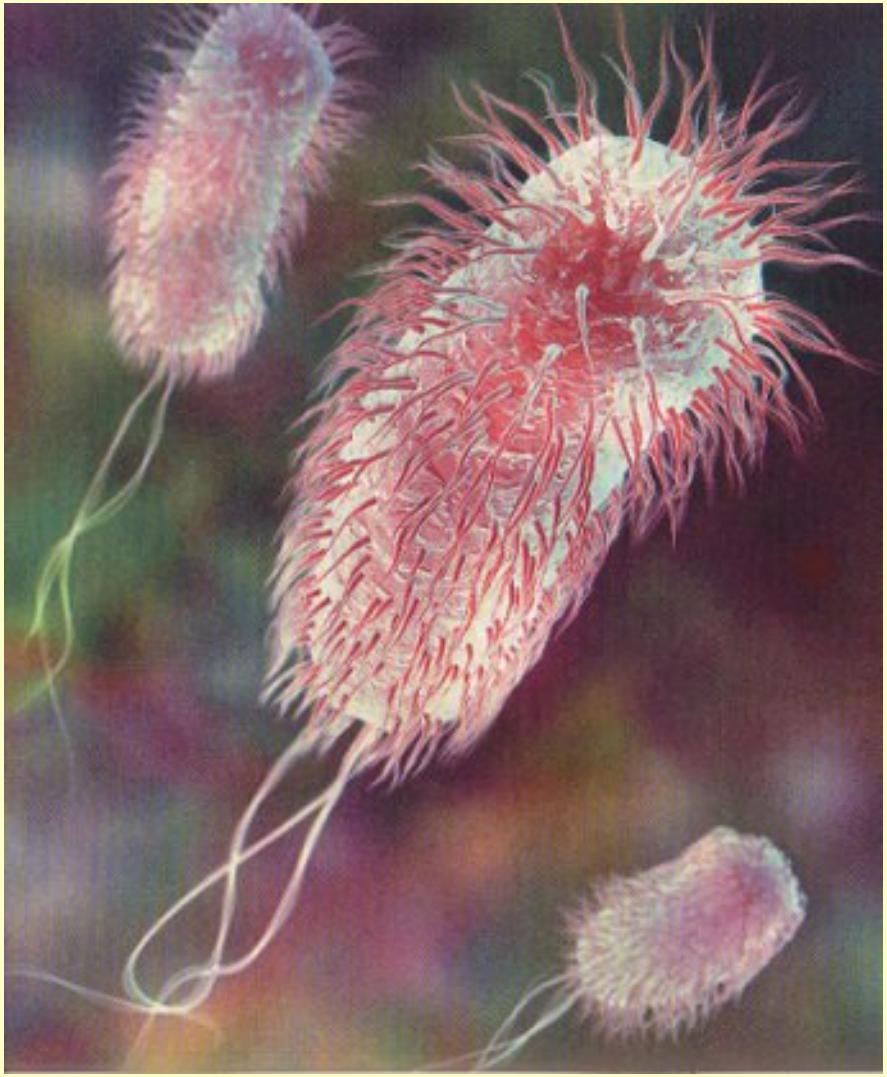
ACO for Parameter Settings of E.coli Fed-batch Cultivation Model

Stefka Fidanova, Olympia Roeva
Bulgarian Academy of Sciences

Escherichia coli

- Interleukins
- Insulin
- Interferon's
- Enzymes
- Growth factors



Problem Formulation

$$\frac{dX}{dt} = \mu_{\max} \frac{S}{k_s + S} X + \frac{F_{in}}{V} X$$

$$\frac{dS}{dt} - \frac{1}{Y_{S/X}} \mu_{\max} \frac{S}{k_s + S} X + \frac{F_{in}}{V} \left(S_{in} - S \right)$$

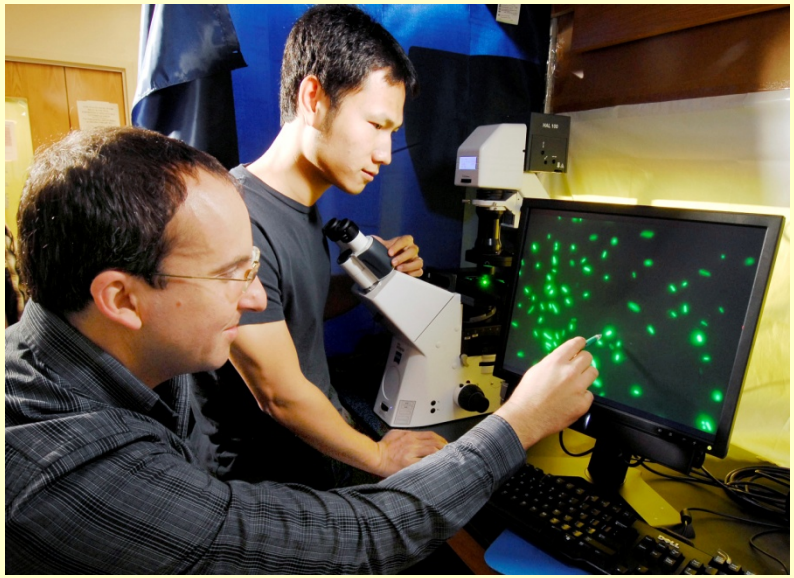
$$\frac{dV}{dt} = F_{in}$$

Problem Formulation

- X – biomass concentration [*g/l*]
- S – substrate concentration [*g/l*]
- F_{in} – feeding rate [*l/h*]
- V – bioreactor volume [*l*]
- S_{in} – substrate concentration in solution
- μ_{max} – growth rate [h^{-1}]
- k_S – saturation constant [*g/l*]
- $Y_{S/X}$ – yield coefficient

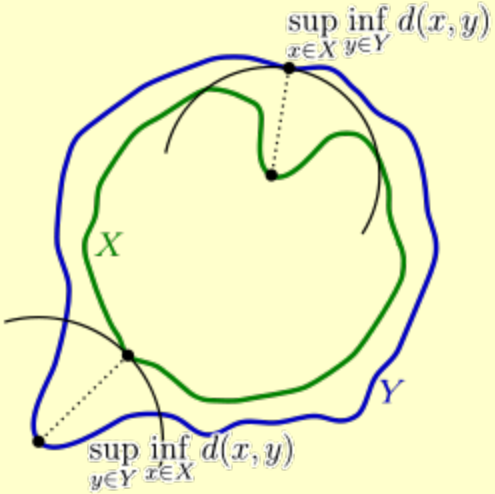
Objective Function

$$y=(X,S)$$



Hausdorff Distance

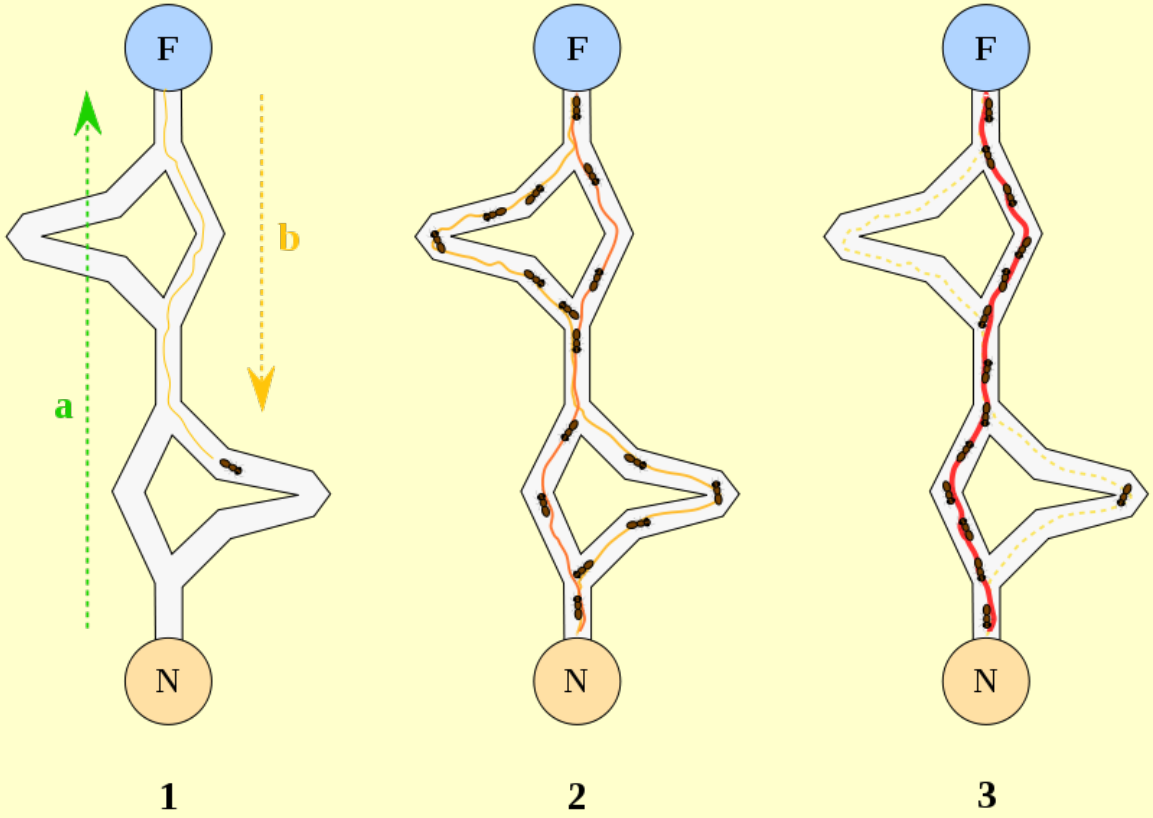
$$d_{\mathrm{H}}(X,Y) = \max\{\, \sup_{x\in X} \inf_{y\in Y} d(x,y),\ \sup_{y\in Y} \inf_{x\in X} d(x,y) \,\},$$



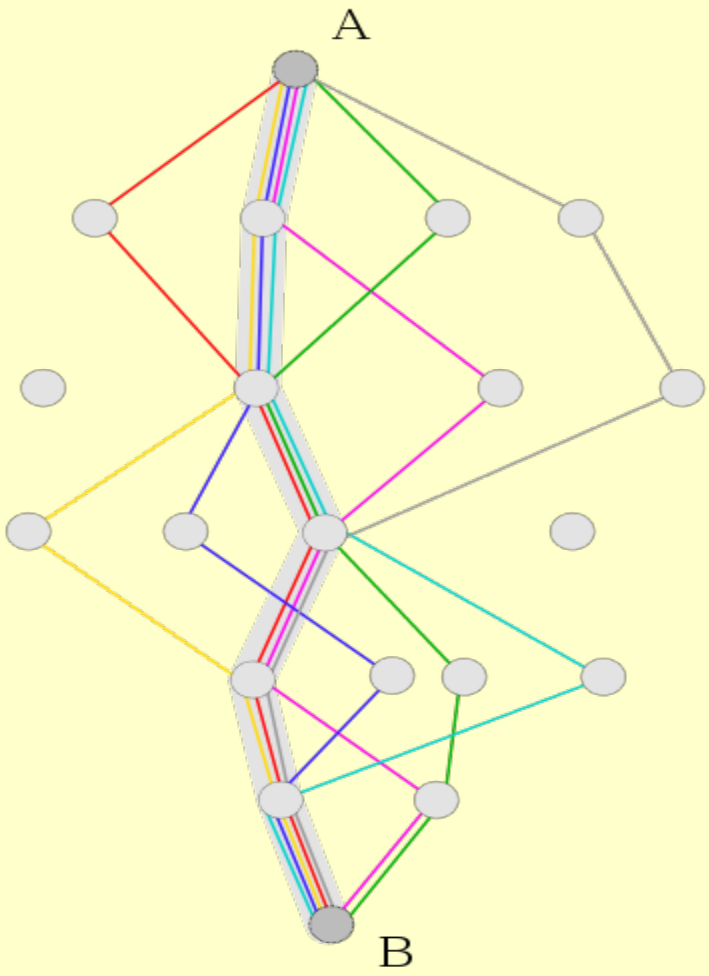
Metaheuristics

- A **metaheuristics** are methods for solving a very general class of computational problems by combining user-given black-box procedures in the hope of obtaining a more efficient or more robust procedure. The name combines the Greek prefix "meta" ("beyond", here in the sense of "higher level") and "heuristic" (from ευρισκειν, *heuriskein*, "to find").
- Metaheuristics are generally applied to problems for which there is no satisfactory problem-specific algorithm or heuristic; or when it is not practical to implement such a method. Most commonly used metaheuristics are targeted to combinatorial optimization problems, but of course can handle any problem that can be recast in that form, such as solving boolean equations

Ant Colony Optimization



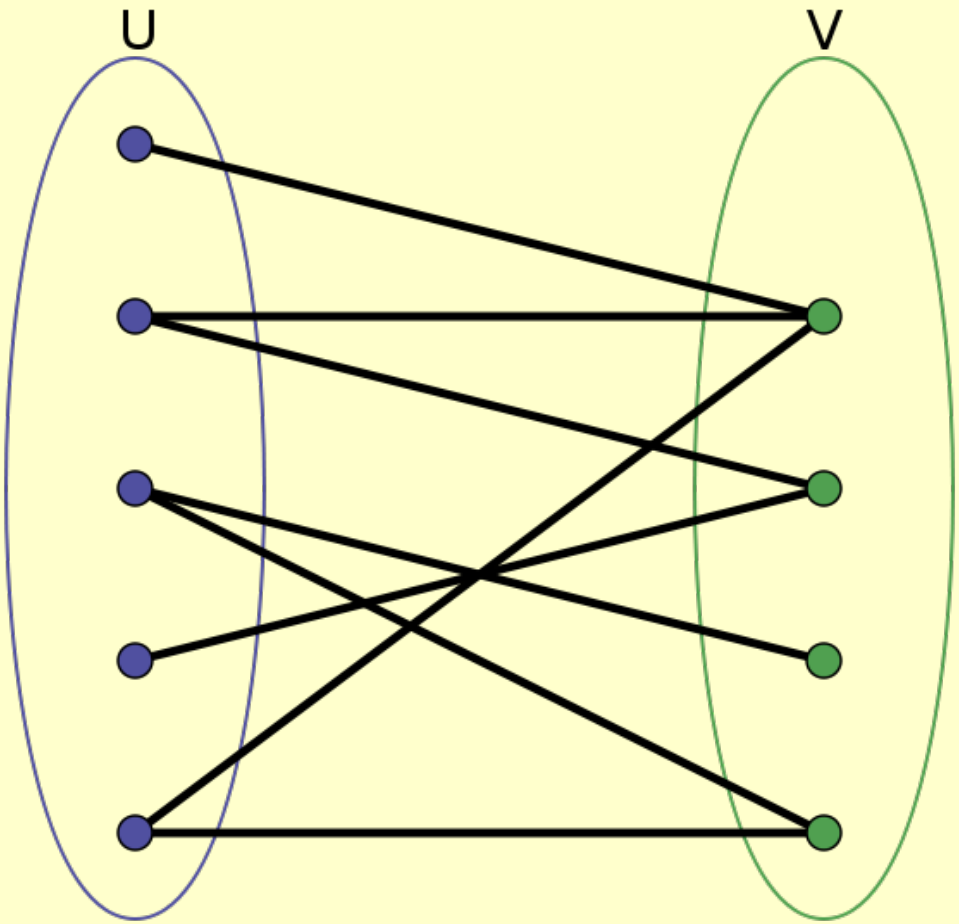
Graph of the Problem



Ant Colony Optimization

Procedure ACO
Begin
initialize the pheromone
while stopping criterion not satisfied **do**
position each ant on a starting node
repeat
for each ant **do**
chose next node
end for
until every ant has build a solution
update the pheromone
end while
end

Three-partitive Graph



Transition Probability

$$\mathrm{Prob}_{ij}^{k}(t) = \begin{cases} \dfrac{\tau_{ij}\eta_{ij}}{\sum_{b \in allowed_k(t)} \tau_{ib}\eta_{ib}} & if \quad j \in allowed_k(t) \\ 0 & otherwise \end{cases}$$

Pheromone Updating

$$\tau_{ij} \leftarrow \rho \tau_{ij} + \Delta \tau_{ij}$$

$$0 < \rho < 1 \quad - \text{evaporation}$$

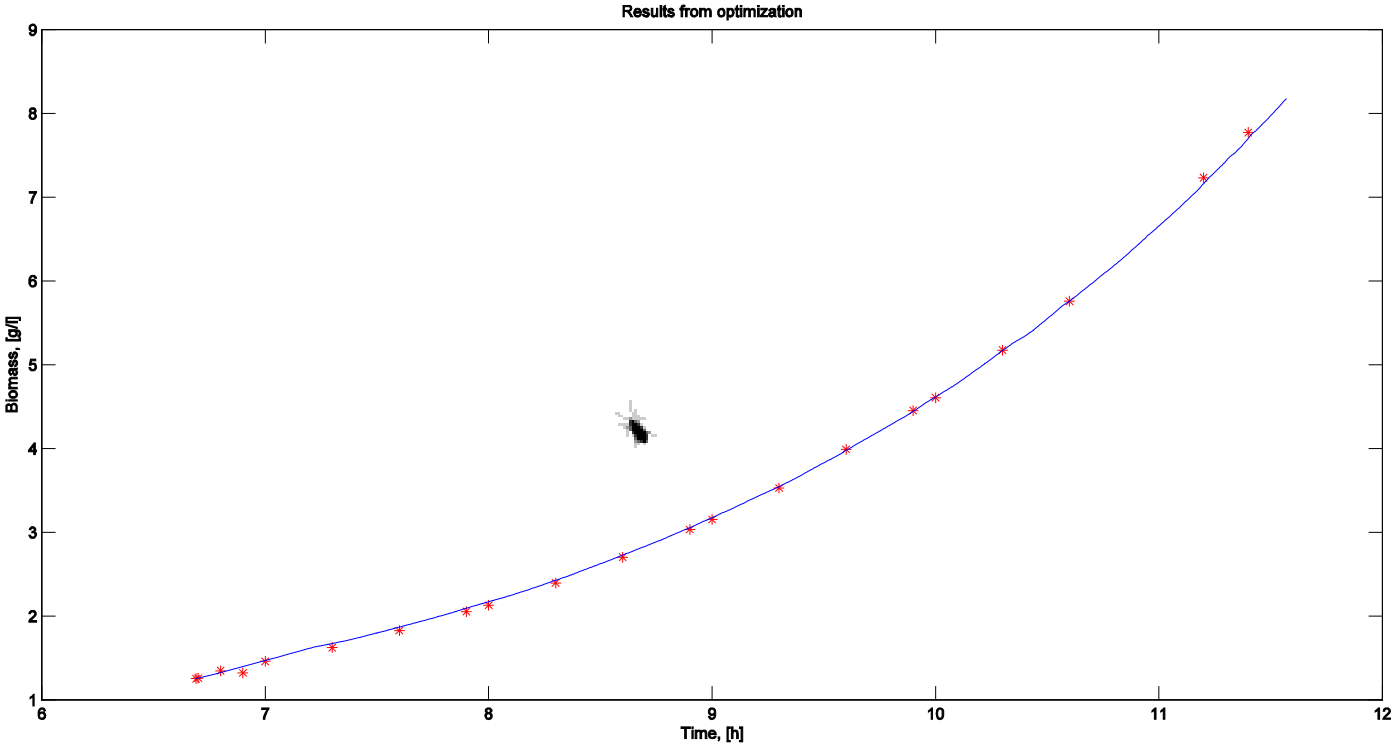
ACO Parameters

Parameter	Value
Number ants	20
Initial pheromone	0.5
evaporation	0.1

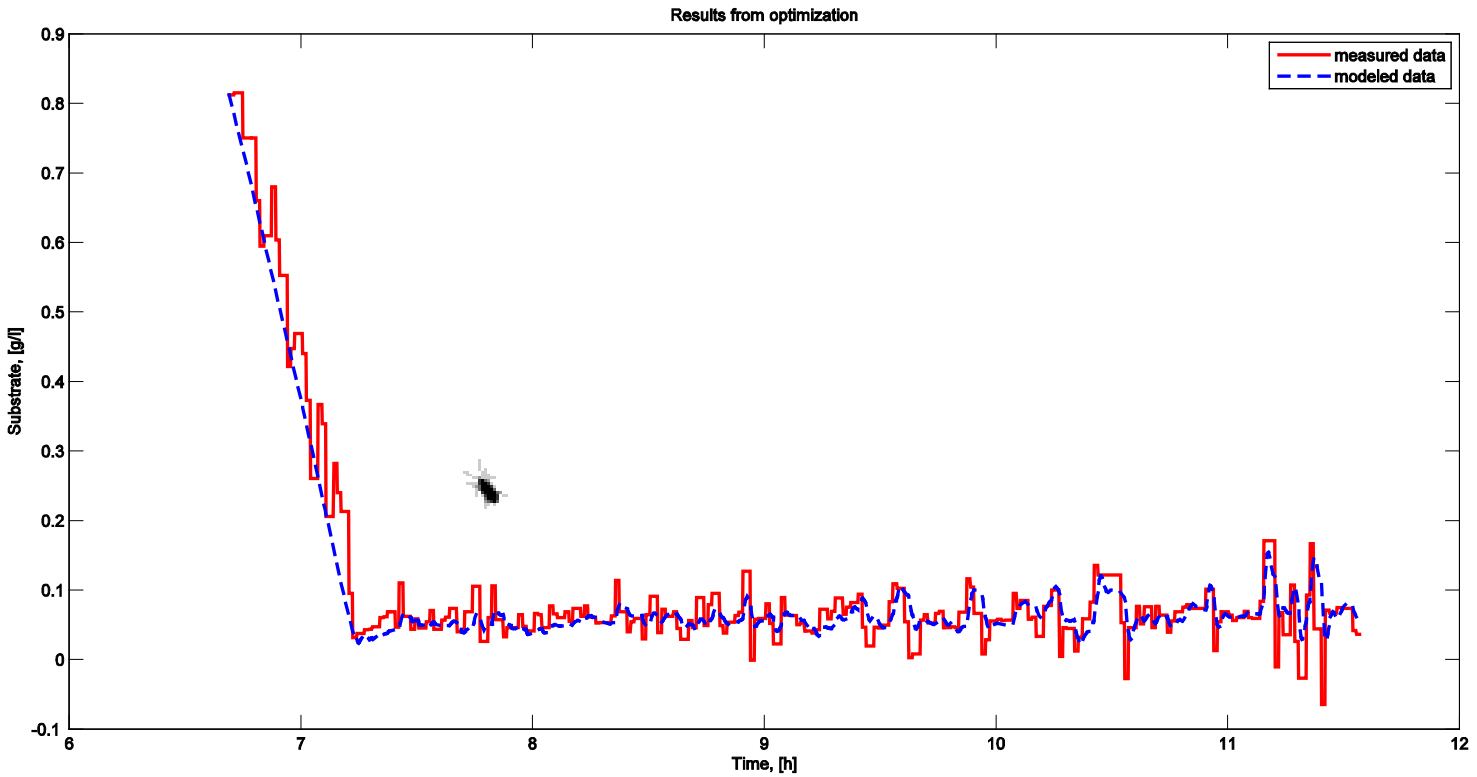
Computational Results

	Method	Average	Worst	Best
ACO LS	-	4.8866	6.7700	3.3280
	Hausdorff	2.3875	4.1290	1.7218
ACO Hdf	-	1.8744	2.5322	1.6425
	Least sqr	3.9706	4.4283	3.4276

Computational Results biomass



Computational Results
Substrate



Thank for Your Attention