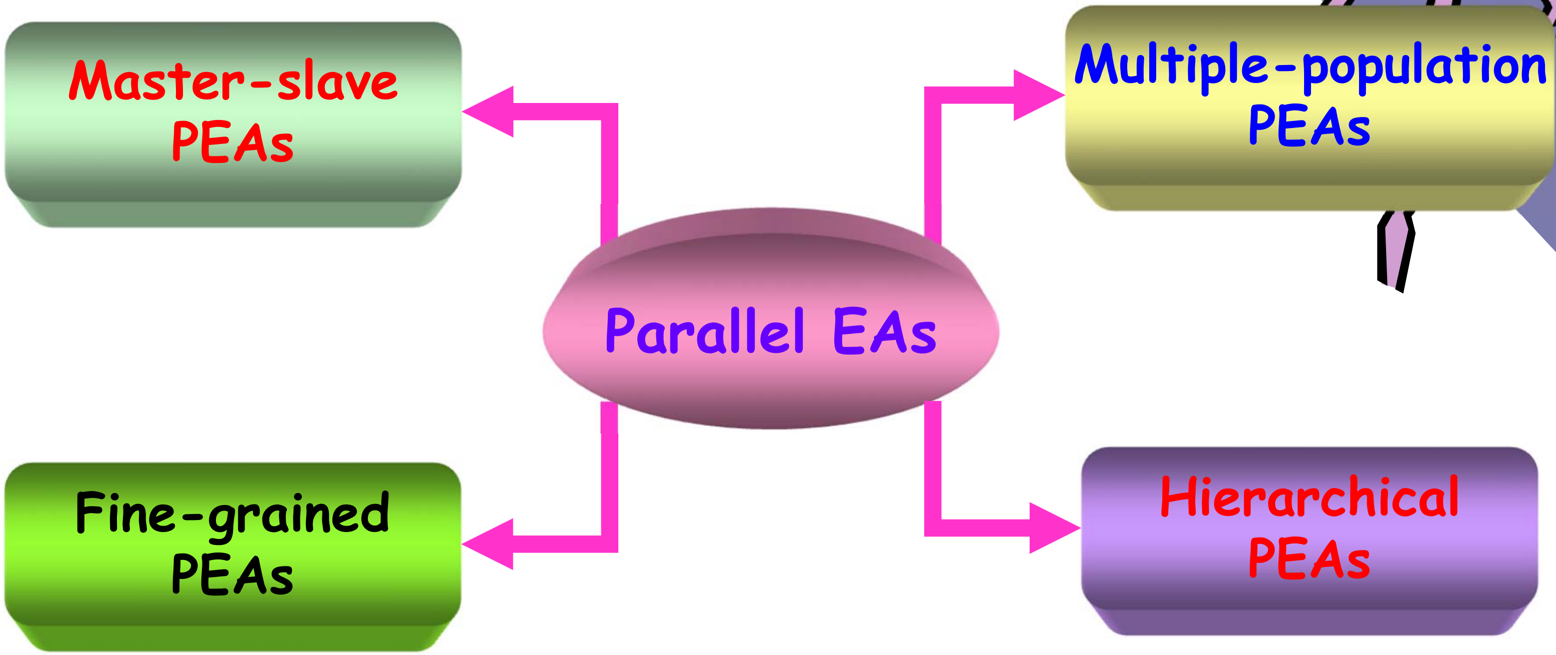
Parallel
Evolutionary
Algorithms

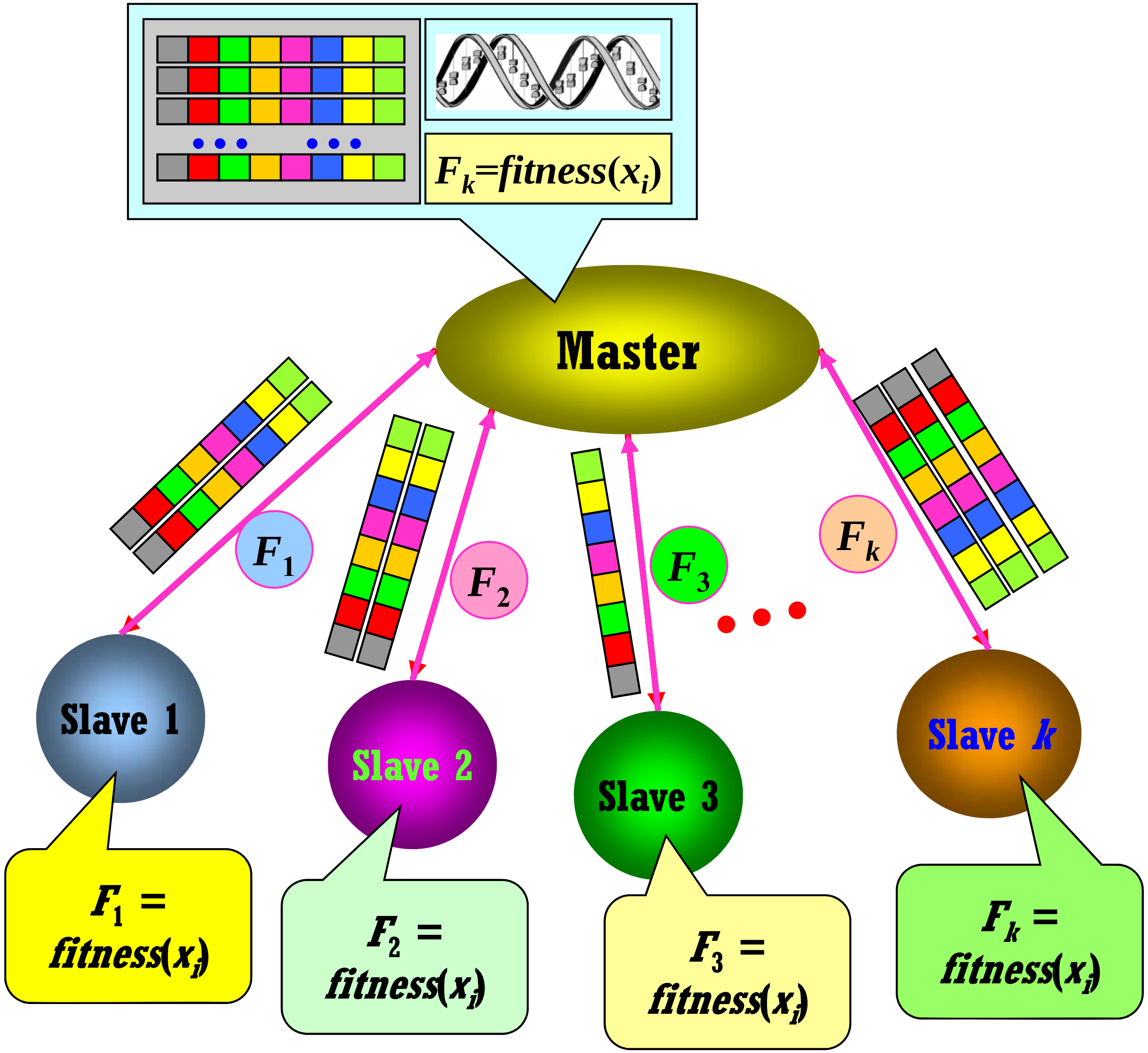
Parallel EAs (1)

- **Why Parallel Evolutionary Algorithms (PEAs) ?**
  - **Evolution itself is a highly parallel process**
  - **EAs are easy to parallelize (i.e., inherent parallelism)**
  - **PEAs can solve difficult problems (i.e., vast search space)**
  - **Parallel mechanism reduces considerably the processing time**
  - **There are tremendous computing resources (i.e., grid computing)**



Parallel EAs (2)

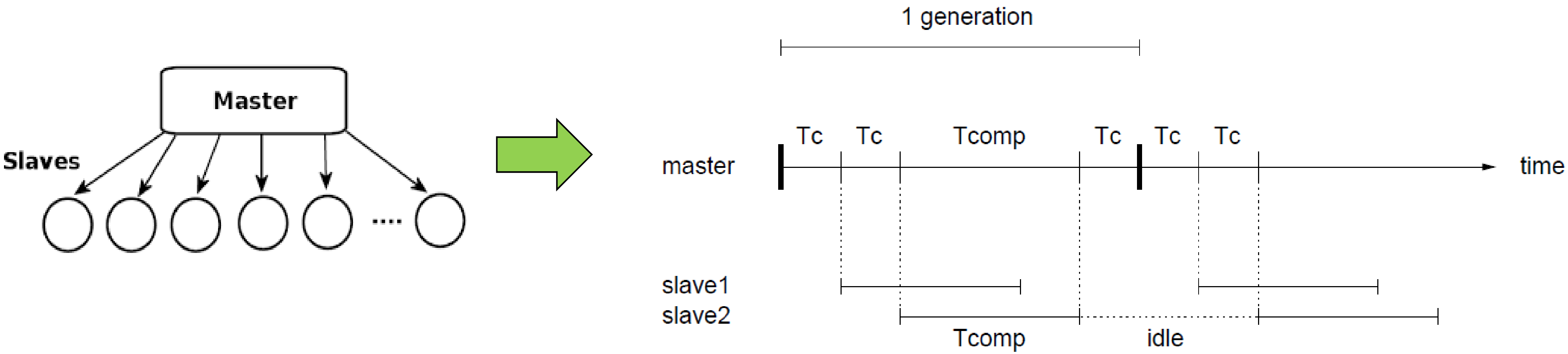
Master-slave PEAs



Parallel EAs (3)

❖ As to Master-Slave PGAs…

➢ How efficient are they? How many slaves?



Considering the contribution from communication and computation, the elapsed time for one gen. can be estimated as

$$T_p = \mathcal{P}T_c + \frac{nT_f}{\mathcal{P}}$$

Total elapsed time

Population size

Evaluation time for one individual

Total number of processors; P=S+1 where S is #Slaves

Communication time

Parallel EAs (4)

❖ As to Master-Slave PGAs…

$$\boxed{T_p = \mathcal{P}T_c + \frac{nT_f}{\mathcal{P}}}$$ ⇨ To find the optimal, let $\frac{\partial T_p}{\partial \mathcal{P}} = 0$ ⇨ $\mathcal{P}^* = \sqrt{\frac{nT_f}{T_c}}$

Thus, the optimal number of slaves becomes $\mathcal{S}^* = \mathcal{P}^* - 1$

➢ **When PGAs Faster than a simple GA?**

$$\boxed{\gamma = T_f / T_c}$$

As long as the elapsed time of PGAs is shorter than that of a simple GA…

The elapsed time of a simple GA

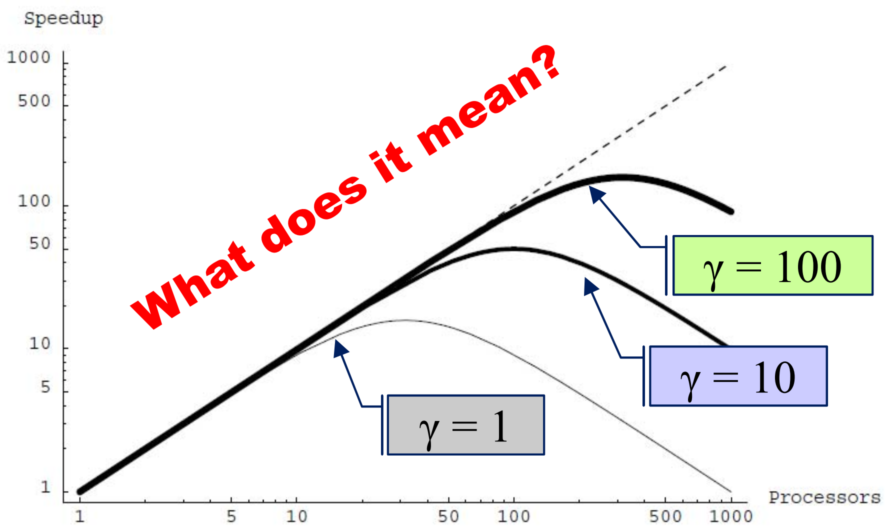
The elapsed time of PGAs

$$\frac{T_s}{T_p} = \frac{nT_f}{\frac{nT_f}{\mathcal{P}} + \mathcal{P}T_c} = \frac{n\gamma}{\frac{n\gamma}{\mathcal{P}} + \mathcal{P}} > 1$$

⇨ $$\boxed{\gamma > \frac{\mathcal{P}^2}{n(\mathcal{P}-1)}}$$

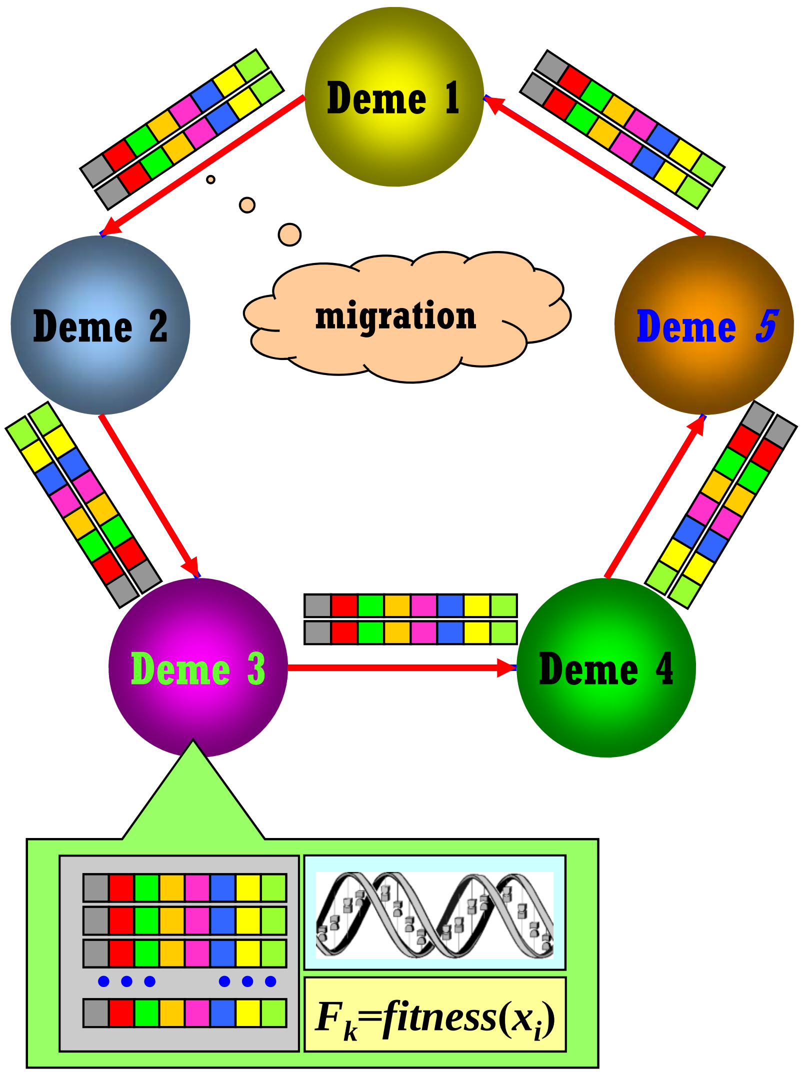
For the minimum number of processors (P=2), the condition is…

⇨ $$\gamma > \frac{4}{n}$$

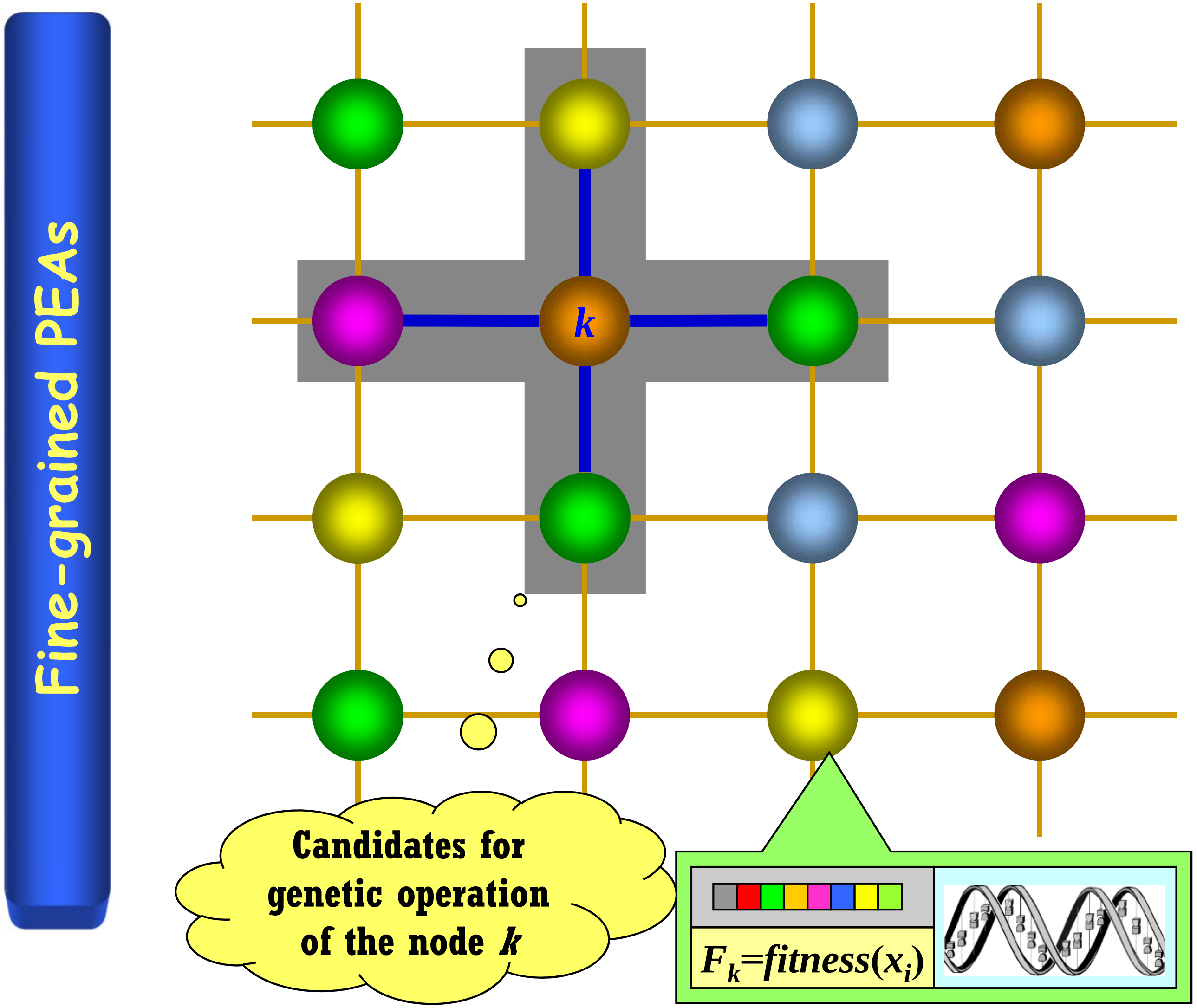


Parallel EAs (5)

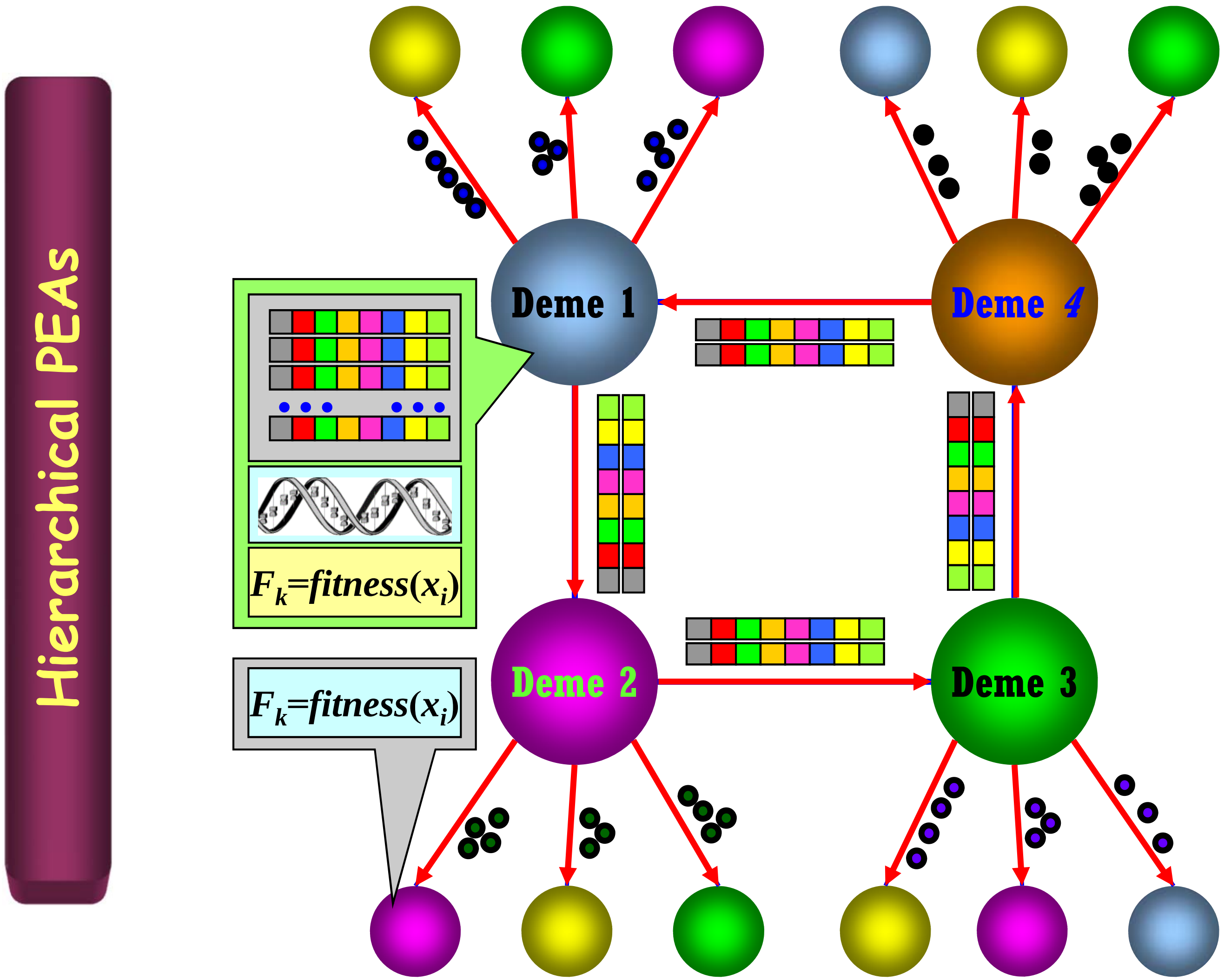
Multiple-population PEAs
(a.k.a. Multi-Deme PEAs)



Parallel EAs (6)



Parallel EAs (7)



Summary

- **Parallel Evolutionary Algorithms (PEAs)**
  - It is natural to make EAs parallel due to their Inherent Parallelism
  - Generally, parallel EAs outperform sequential EAs
  - ➔ Also, the topology and the migration of PEAs are important topics in PEAs!