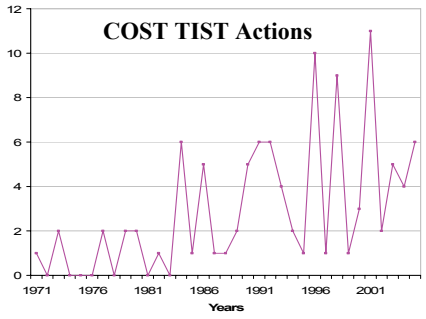
Evolutionary Algorithms in Telecommunications

LENGUAJES Y CIENCIAS DE LA COMPUTACIÓN
UNIVERSIDAD DE MÁLAGA

Enrique Alba and Francisco Chicano

Introduction

- Fast development of network infrastructures, cellular networks, software, and Internet services
- New services and applications appear: e.g. videophones
- Great interest in Telecommunication problems



- New algorithms improving the exact ones are needed

Index

• We classify the following problems in four categories:

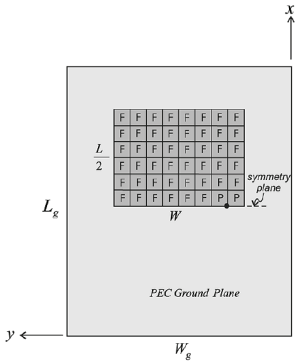
- Hardware Design
- Data Transmission
- Network Design
- Other Problems

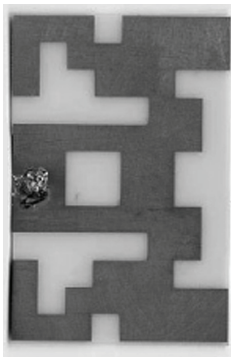
Hardware Design Problems

MELECON 2006

Patch Antennae Design

- Topological design of a patch antenna for wireless networks optimizing some electrical aspects
- One evaluation requires a time consuming electromagnetic analysis
- Villegas et al. (2004) use a Parallel Genetic Algorithm

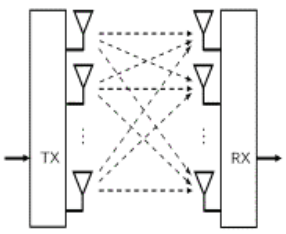




MELECON 2006

Antenna Selection in MIMO Systems

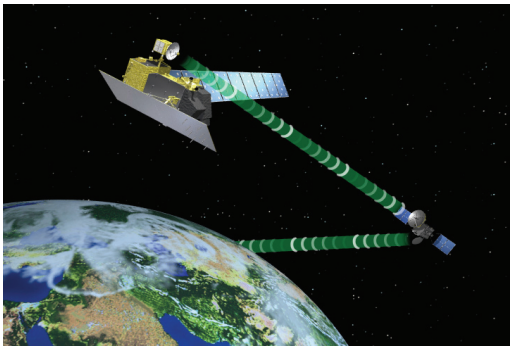
- Selecting a subset of antennae in the transmitter and receiver maximizing the link capacity
- The capacity depends on the propagation medium
- In COST Action 273 (2001-2005) *Towards Mobile Broadband Multimedia Networks* a Genetic Algorithm is used



MELECON 2006

Introduction
HW Design
Data Transm.
Network Design
Other Problems
Conclusions

Data Transmission Problems

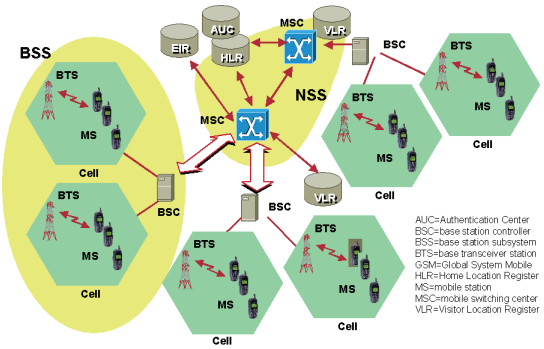


MELECON 2006

Introduction
HW Design
Data Transm.
Network Design
Other Problems
Conclusions

Frequency Assignment Problem

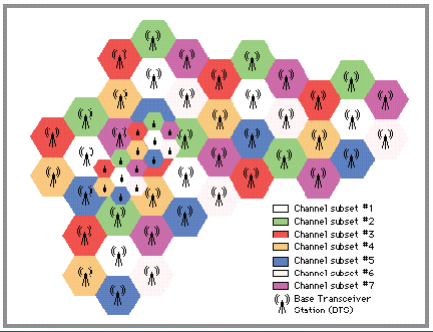
- Assigning frequencies to radio links minimizing the amount of different frequencies
- The assignment must fulfill some constraints to avoid interferences
- In CALMA project (1992-1995) *Combinatorial Algorithms for Military Applications* a Genetic Algorithm is used for this problem
- Hurley et al. (1994) use a Parallel Genetic Algorithm



MELECON 2006

Dynamic Channel Assignment

- Assigning frequencies to cells dynamically depending on the traffic demand to minimize the blocking probability
- Kwok (1994) use a Parallel Genetic Algorithm
- Some possible scenarios are solved in an offline stage with a Parallel Genetic Algorithm
- An online module selects the precalculated solution corresponding to the nearer traffic demand and refines the solution

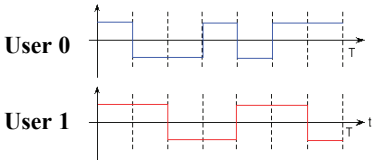


MELECON 2006

Low Correlation Codebook in CDMA

- Designing a codebook with low correlation to minimize the interferences in a UMTS network
- In COST Action 231 (1989-1993) *Digital Mobile Radio towards Future Generation Systems* a Genetic Algorithm is used for this problem

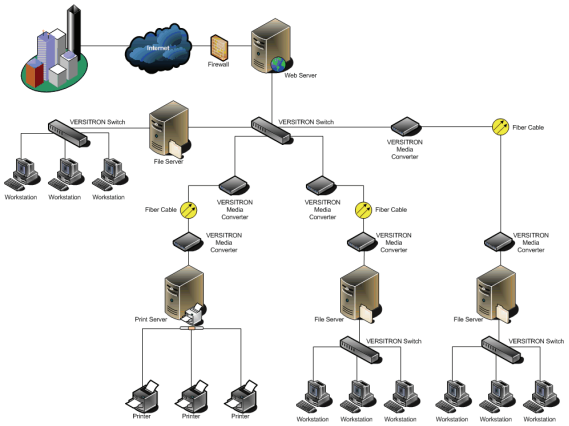
Example of orthogonal codes



Correlation (dot product): 0

MELECON 2006

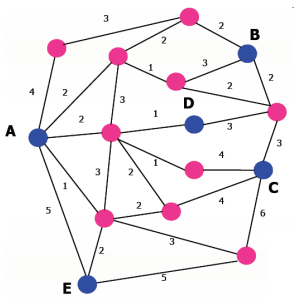
Network Design Problems



MELECON 2006

2-connectivity Network Design

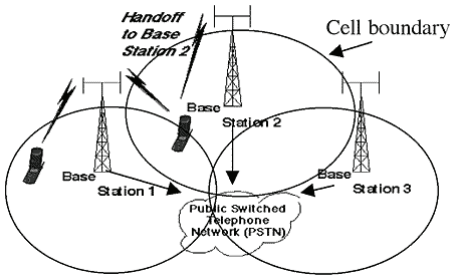
- Obtaining a minimum cost graph with at least two disjoint paths between any pair of terminals
- Connectivity among the terminals is assured on a link or node failure
- Huang et al. (1997) use a Parallel Genetic Algorithm



MELECON2006

Antenna Placement and Config.

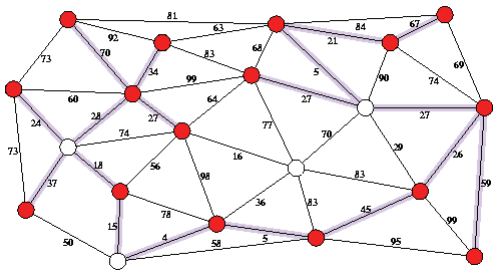
- Deciding antennae placement and parameters minimizing the number of sites, maximizing the amount of traffic, and minimizing the interferences
- Solutions must fulfill some coverage and handover constraints
- Meunier et al. (2000) use a Parallel Multiobjective Genetic Algorithm with a multilevel encoding



MELECON2006

Steiner Tree Problem

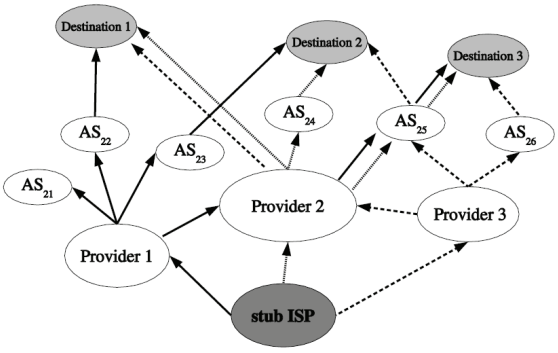
- Obtaining a minimum cost subtree of a graph including a set of terminal nodes
- It has applications in Internet multicast routing
- Lo Re et al. (2004) solve the problem with two Parallel Genetic Algorithms (master-slave and distributed)



MELECON2006

Interdomain Traffic Engineering

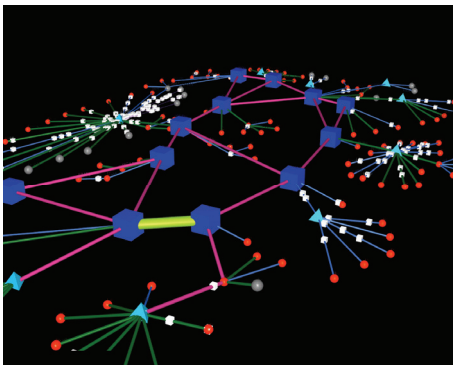
- Deciding which internet service provider to choose for each autonomous system in order to minimize the total cost due to internet services
- In the ATRIUM project (2001-2003) *A Testbed of terabit IP routers rUnning MPLS over DWDM* the problem is tackled with Genetic Algorithms



MELECON2006

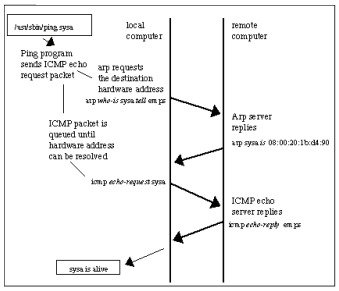
Virtual Path Routing Optimization

- Establishing routes for virtual paths in virtual circuits oriented networks in order to minimize the maximum link utilization
- The result is a distribution of the traffic that improves the reliability of the network and minimizes the probability of call blocking
- Eren and Ersoy (2001) solves the problem with a Parallel Annealed Genetic Algorithm



MELECON 2006

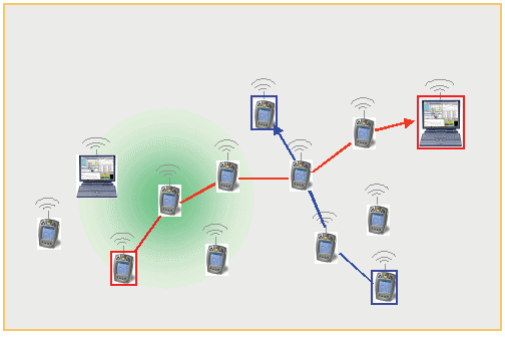
Other Problems



MELECON 2006

Optimal Broadcasting in MANETs

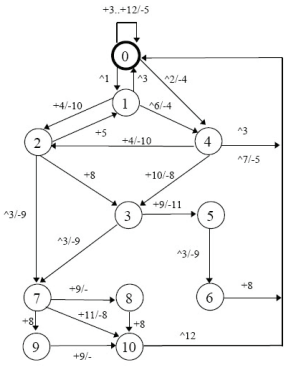
- Tuning a broadcasting protocol for MANETs to reach the maximum number of stations, minimize the network utilization, and to minimize the makespan
- Alba et al. (2005) solve this problem with Cellular Multiobjective Genetic Algorithm



MELECON 2006

Protocol Validation

- Test network protocols to check correctness. The objective is to find errors in the protocols
- Alba and Troya (1996) use a Genetic Algorithm to validate the TCP protocol
- Godefroid and Kurshid (2002) validate the Needham-Schroeder protocol with a Genetic Algorithm



MEANING OF THE STATES

0	CLOSED
1	LISTEN
2	SYN RECVD
3	ESTABLISHED
4	SYN SENT
5	CLOSE WAIT
6	LAST ACK
7	FIN WAIT-1
8	CLOSING
9	FIN WAIT-2
10	TIMED WAIT

MEANING OF THE I/O MESSAGES

1	passive_open	7	time-out
2	active_open	8	ack
3	close	9	fin
4	syn	10	syn+ack
5	reset	11	fin+ack
6	send	12	wait

MELECON 2006

Conclusions

- Due to the Telecommunication technology evolution new problems arise in these domain
- The size of existing telecommunication infrastructure is enlarging and the underlying optimization problems pose a challenge to existing algorithms
- There are many telecommunication problems intractable with exact techniques
- Evolutionary Algorithms are applicable in these problems

MELECON 2006

THE END

Thanks for your attention !!!