Vertical Handover Decision Strategies

A double-sided auction approach

Working paper

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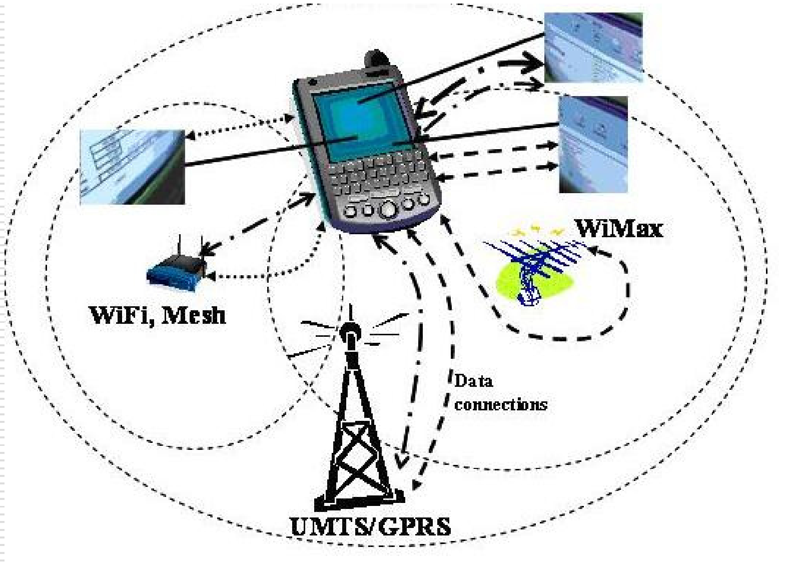
Content

Introduction

- **The evolution of various wireless technologies**
  - 3G, 4G, WLAN, WMAN
  - Difference of wireless access, bandwidth, cost, latency

- **Connectivity to IP services anytime, anywhere**

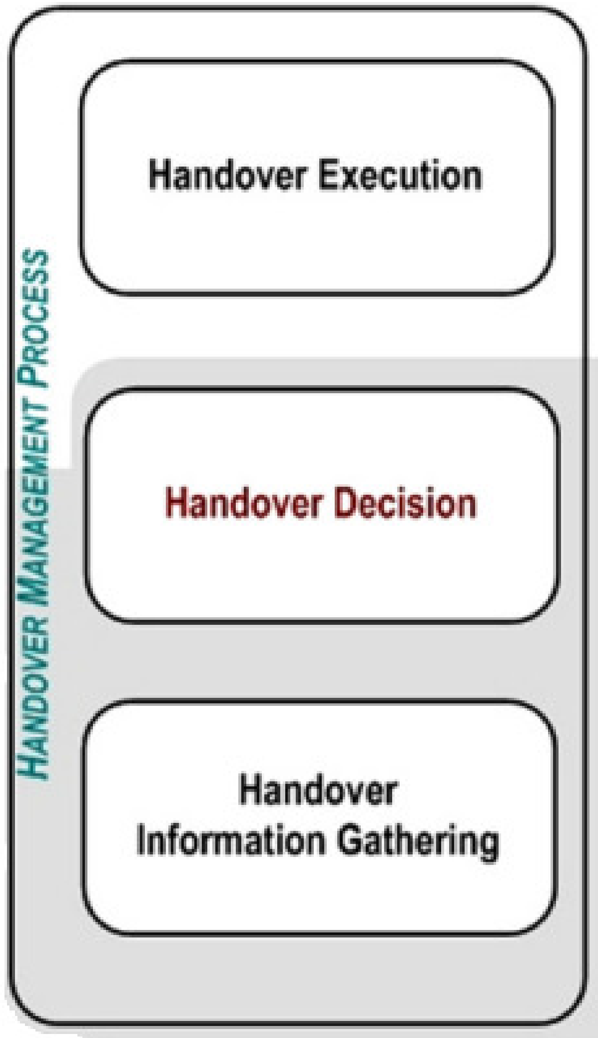
- **QoS is a crucial issue**
  - Always Best Connected (ABC) concept



Handover in heterogeneous networks

- Mobility management involves
  - Horizontal handover
  - **Vertical handover:** a process help MT maintaining connectivity while moving between heterogeneous networks
- Major challenges in vertical handover
  - Seamless
  - **Automation aspects in network switching**
- Focus on the vertical handoff decision problem
  - Decision criteria, policies, algorithms, control scheme
  - Decision criteria may include user preference, network conditions, application requirement, and terminal capabilities.

Handover in heterogeneous networks



Enforce handover

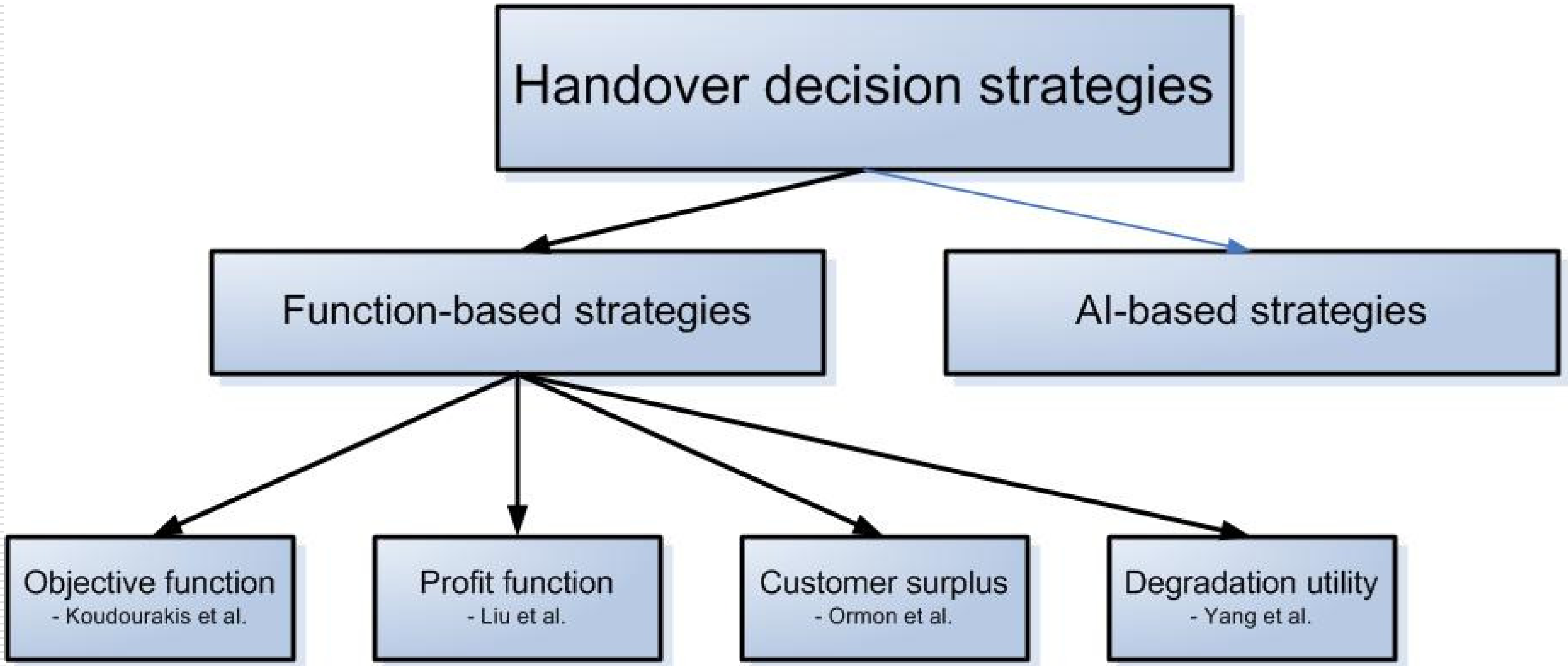
Determine when, and how to handover by selecting suitable network.

Handover initialization/
System discovery

Handover management process

Handover decision strategies

- Function-based strategies
  - Measurement of the benefit obtained by handling over particular parameters



Handover decision strategy classification

Handover decision strategies

- Discussion on previous schemes
  - Derived from different factors to make decision
  - Who is better in control of handover?
    - Mobile-assisted handover
    - Network-assisted handover
  - Difficult to make an evaluation comparison
  - Ultimately goal is to provide good bandwidth allocation, with optimization of QoS handover (in term of cost, delay, application requirement, etc).
  - Computational constrains to Mobile-assited handover

Auctions in Handover Decision Strategies

- What's auction
  - An important application of *mechanism design*
  - Implement *social choice* in strategic setting
  - Auctioneer, seller, and buyer

- Type of auctions
  - Single-sided auction, Double-sided auction
  - First price auction
  - Second price sealed-bid auction
  - VCG auction
    - VCG payment is the opportunity cost that their presence introduces to all the other players.

Auctions in Handover Decision Strategies

- Motivation
  - Second proposal apply auction to vertical handover
  - Double-sided auction is more efficient than one-sided auction
  - Benefit nice properties from VCG auctions
    - Incentive-compatible
    - Individually rationality
    - Efficiency (in term of total social welfare)
  - Optimization of bandwidth using at both mobile terminal and network providers
  - Can be applied on both mobile-assisted handover and network-assisted handover

Auctions in Handover Decision Strategies

- Mathematical model
  - There is a set of *n* networks, *m* mobile nodes
  - User/ Mobile node submits a buy bid (b_i, τ_i)
  - Network *j*th provides a sell bid (a_j, λ_j)
  - Handover is determined an handover allocation (x^*, y^*) as following optimization

$$\max_{x,y} \sum_i b_i x_i - \sum_j a_j y_j$$

subject to

$$\sum_j y_j - \sum_i x_i \geq 0$$

$x_i \geq \tau_i > 0$ and $0 < y_j \leq \lambda_j$

Auctions in Handover Decision Strategies

VCG payment determined at buyers/sellers

$$\rho_{buyer} = (\sum_{k \neq i} b_k \tilde{x}_k^{-i} - \sum_j a_j \tilde{y}_j^{-i}) - (\sum_{k \neq i} b_k \tilde{x}_k - \sum_j a_j \tilde{y}_j)$$

$$= \sum_{k \neq i} b_k (\tilde{x}_k^{-i} - \tilde{x}_k) - \sum_j a_j (\tilde{y}_j^{-i} - \tilde{y}_j)$$

$$\rho_{seller} = \sum_i b_i (\bar{x}_i^{-j} - \tilde{x}_i) - \sum_{k \neq j} a_k (\bar{y}_k^{-j} - \tilde{y}_k)$$

where

$(\tilde{x}, \tilde{y})$ is the solution outcome from optimization

$(\tilde{x}^{-i}, \tilde{y}^{-i})$ is the solution from optimization without buyer i

$(\bar{x}^{-j}, \bar{y}^{-j})$ is the solution from optimization without seller j

Auctions in Handover Decision Strategies

- **Theorem 1**: *Solution outcome of the optimization is an efficient Nash equilibrium of our pricing game.*
- **Theorem 2**: *Truth-telling is the dominant strategy in our pricing game.*

Conclusion

- Advantages
  - Optimization of cost, bandwidth using at mobile nodes and network routers
  - Benefit from nice properties from auction theory
    - Efficiency, individual rationality, incentive compatibility
    - Converge to a Nash equilibrium
  - Can be applied to Mobile-assisted handover and Network-assisted handover schemes
  - Support multi-homing
    - Mobile node can maintain IP-connectivity with more than one AP of different technologies
- Drawbacks
  - Limited input parameters
  - Budget-balance problem