GreenCoop: Cooperative Green Routing with Energy-efficient Servers

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Motivations

Internet Service Providers (ISP) are becoming sensitive to reducing the power consumption of their infrastructure

- increasing energy costs
- new business opportunities that can be realized by "going green"

Also Content Providers (CP) are faced with energy issues

- constant increase in the number of users
- need to reducing the energy consumption of both server farms and cooling systems.

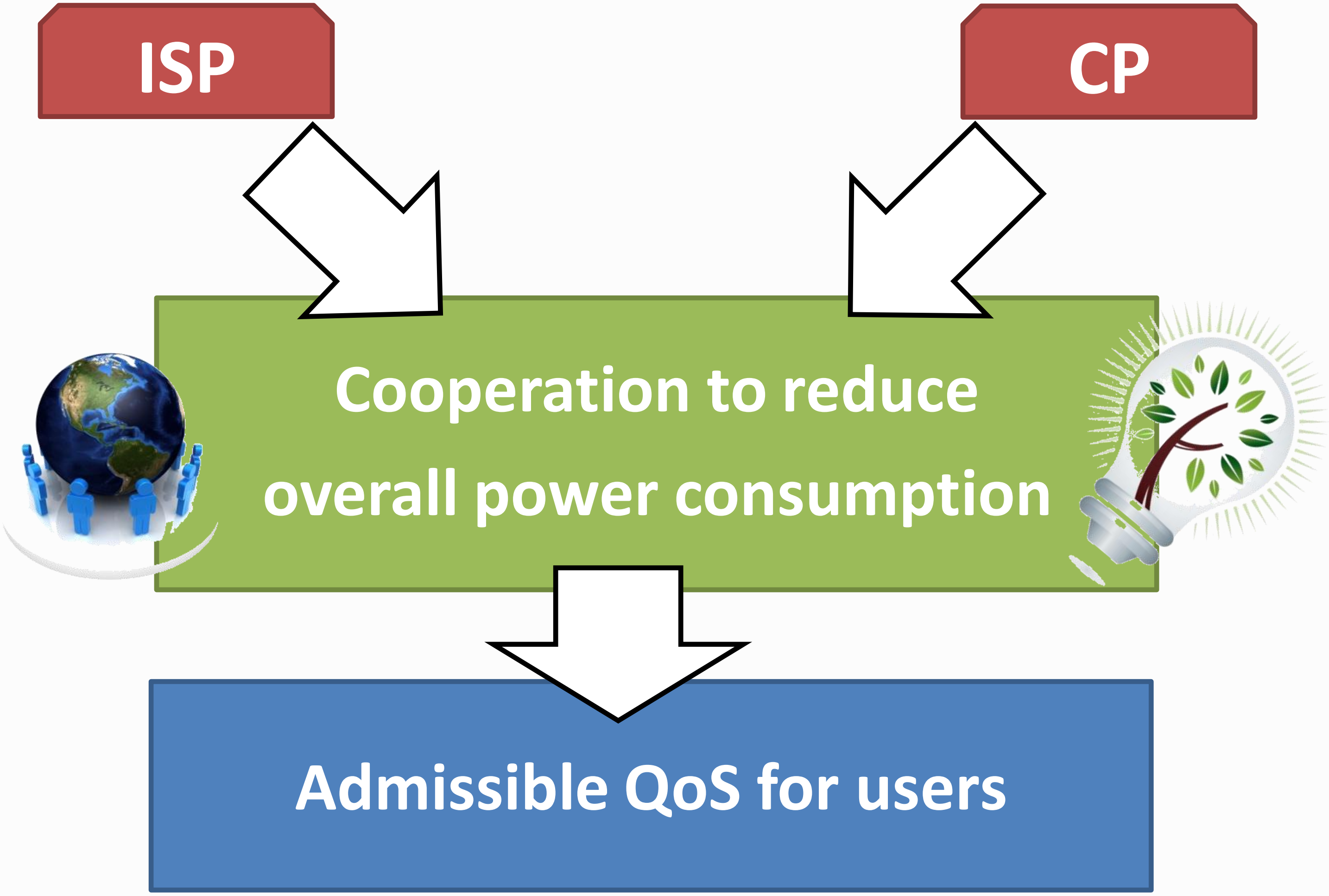
Previous Work

Impact on CP power consumption? — ISP

Impact on ISP power consumption? — CP

Impact on total power consumption? — ISP, CP

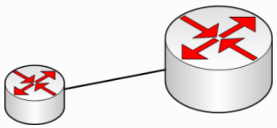
Our Approach



Assumptions

- We consider the case of one CP and one ISP.

- The ISP is the owner of a network infrastructure.



- The CP manages a set of servers, connected to the ISP network.

- Users ask for CP's resources, under QoS constraints.

- Each user can be potentially served by *any* of the servers of the CP, since the resources are replicated over the CP infrastructure.

GreenCoop Model

Minimize

CP Power Consumption + ISP Power Consumption

Subject to

CP

- Traffic demands are split over the set of servers
- Maximum Server Load.
- Variation of electricity prices.

ISP

- Source Destination Traffic is split over the set of paths.
- Connectivity Constraint.
- Maximum Link Utilization.
- Maximum Admissible Delay.

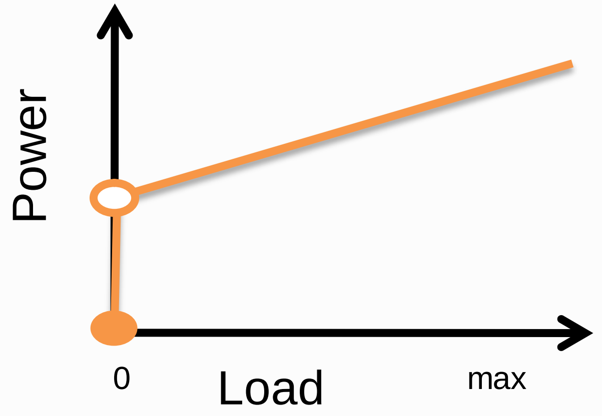
Shared Information

System Parameters

- We use the ISP backbone topologies obtained from RocketFuel.
- We pre-compute up to two disjoint paths for each source-destination pair.
- Links can be utilized up to 50% of their capacity.
- CP infrastructure is composed by 15 servers, placed in the largest cities.
- Traffic demand of clients is modeled according to a Pareto distribution.

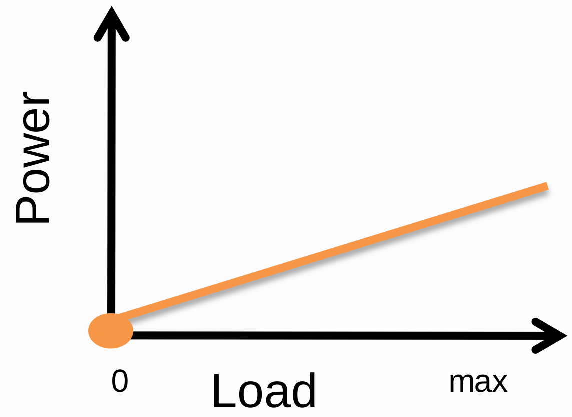
Power Consumption Model

Routers, Servers



Static Power + Dynamic Power

Links



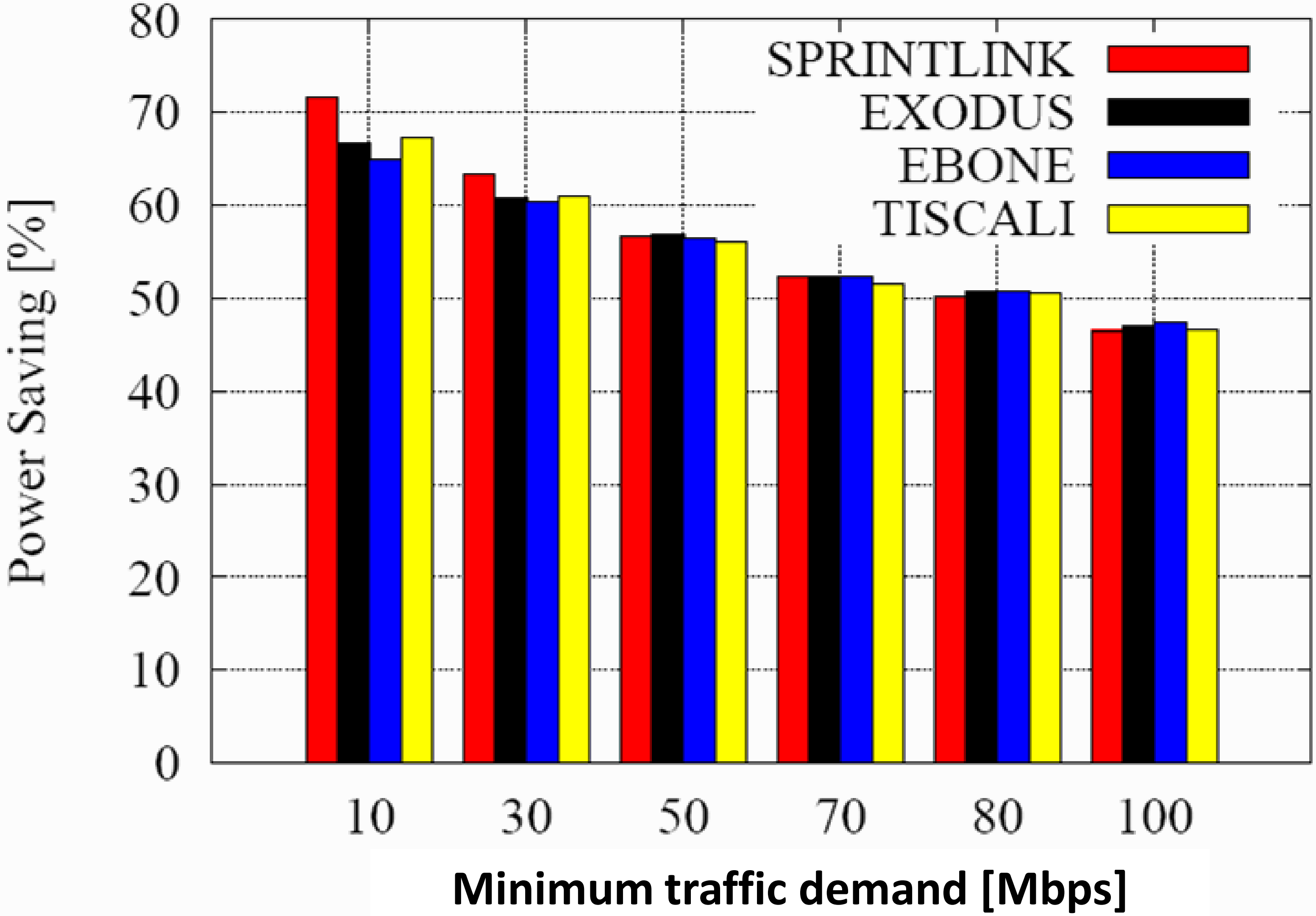
Dynamic Power

Dynamic link power depends also on the number of amplifiers.

For each link, we randomly assign the number of amplifiers (up to 5).

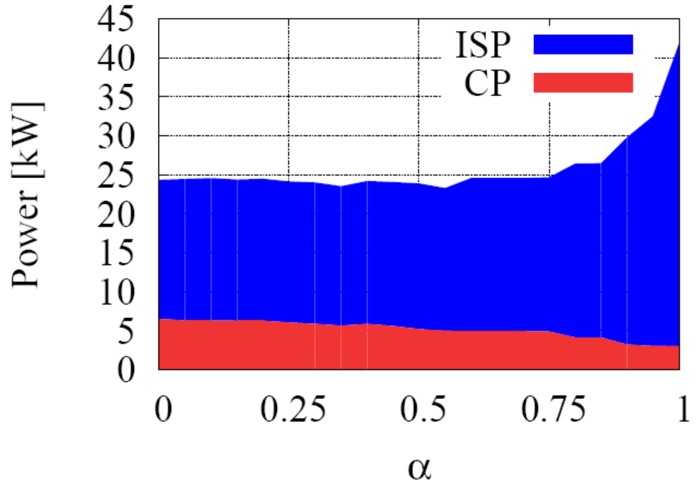
We introduce a 50% random variation of the servers power consumption to model energy price fluctuation.

Power Saving vs Traffic Variation

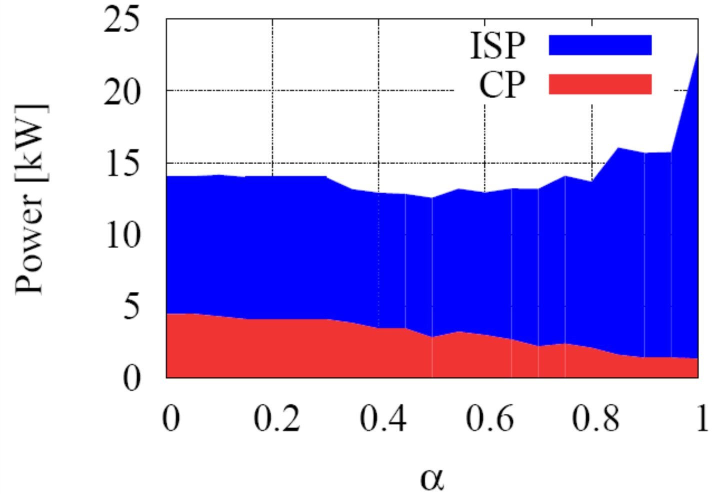


Power Objective Variation

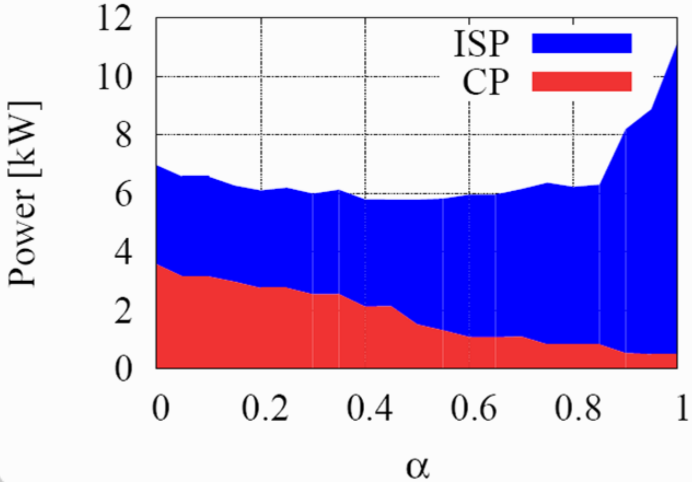
$$\alpha P_{CP} + (1 - \alpha) P_{ISP}$$



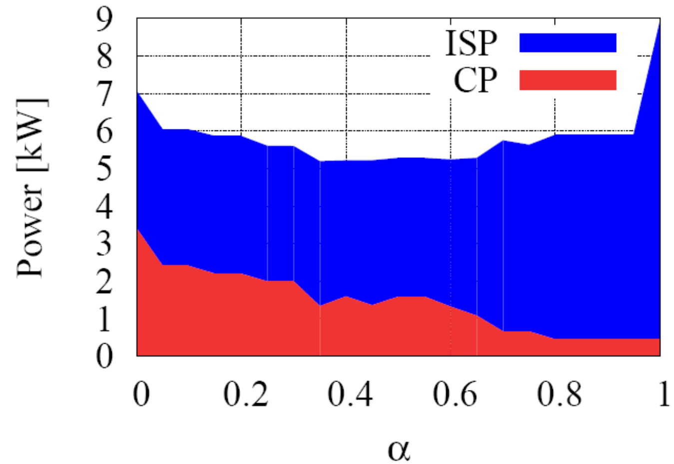
SprintLink



Exodus

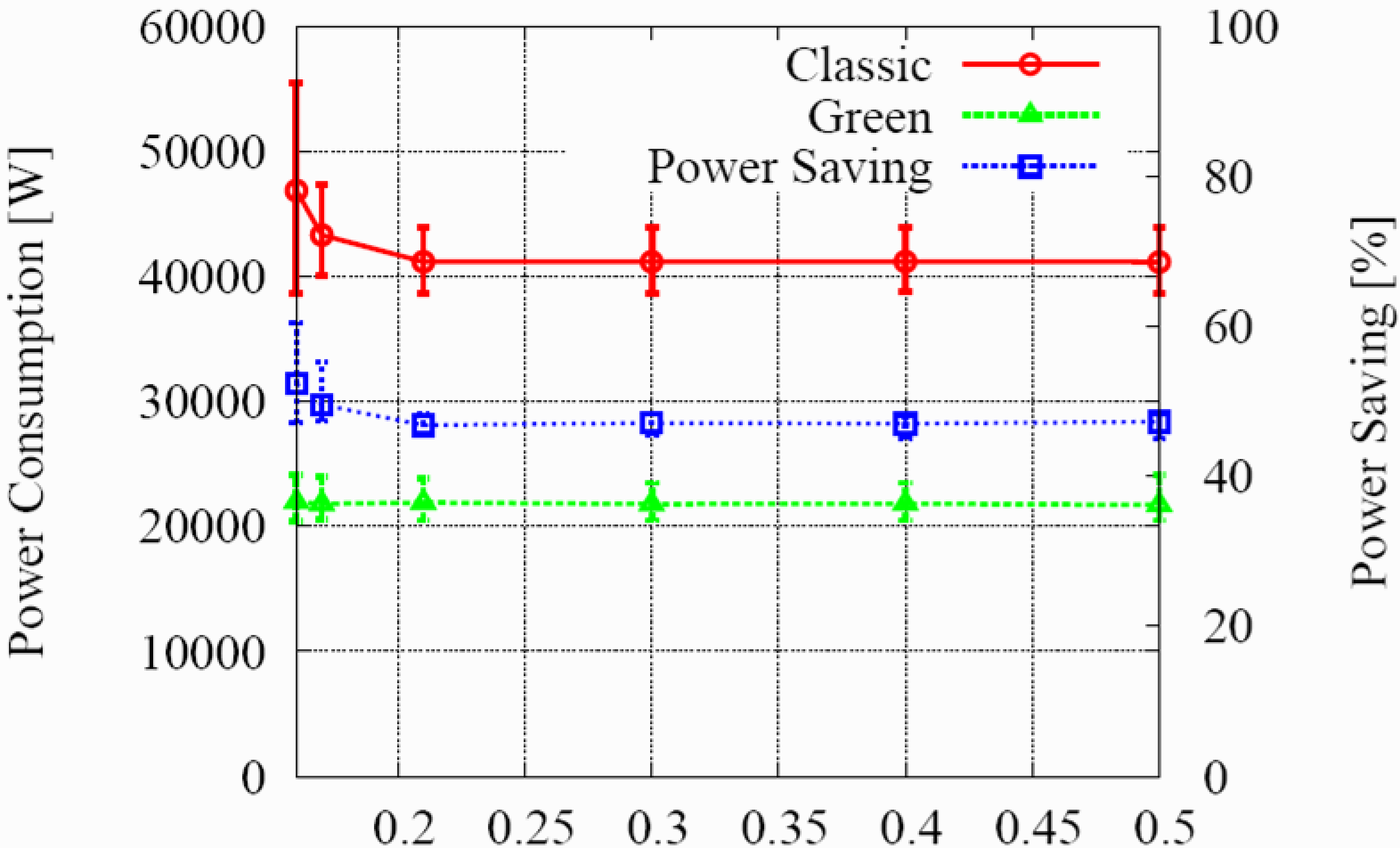


Tiscali



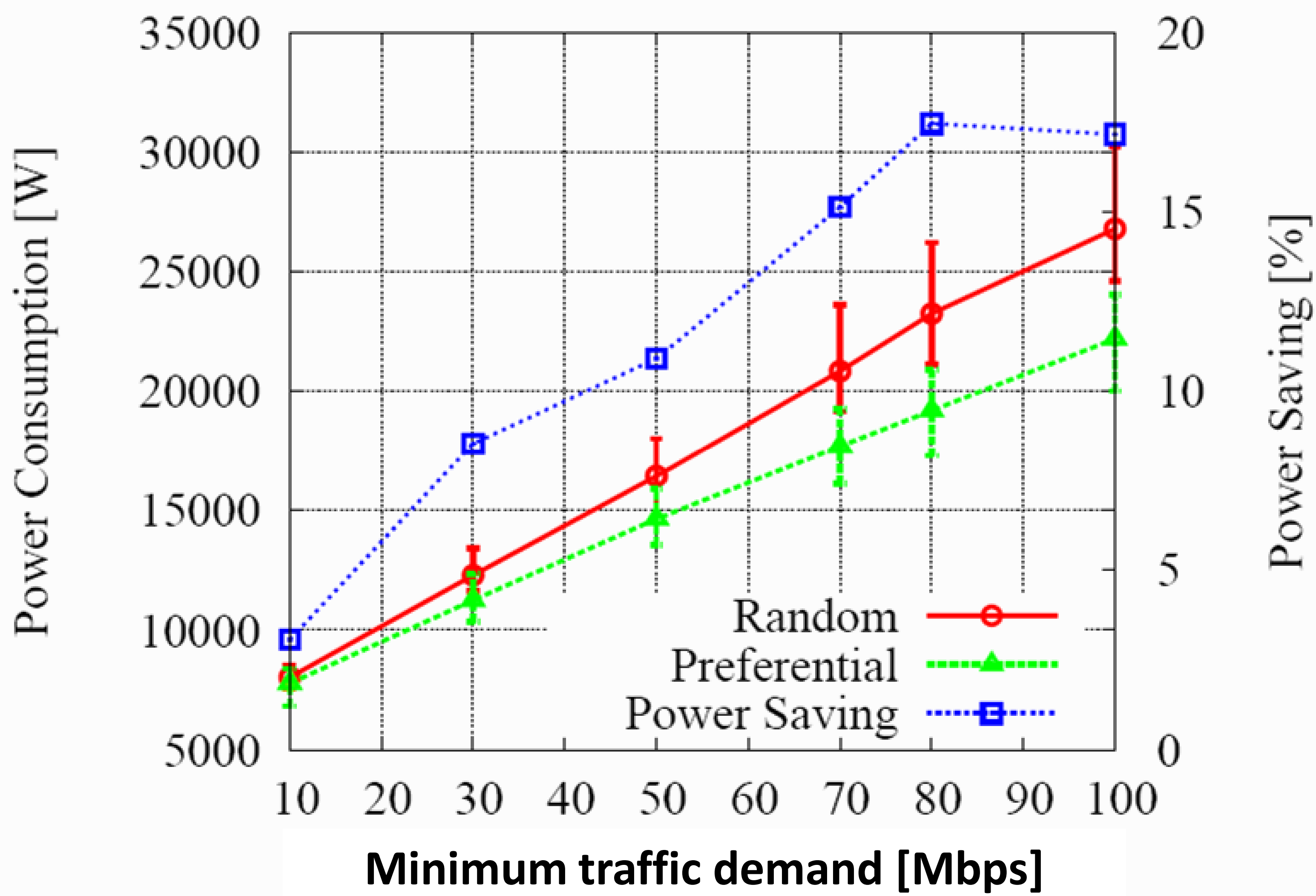
Ebone

Maximum Delay Variation



Maximum admissible delay [s]

Impact of Servers Placement



Conclusions

Energy-aware cooperative design

- Minimize overall power consumption between an ISP and a CP
- Huge power savings compared to classical models
- Common objective function is crucial
- Impact of servers placement on the total power consumption

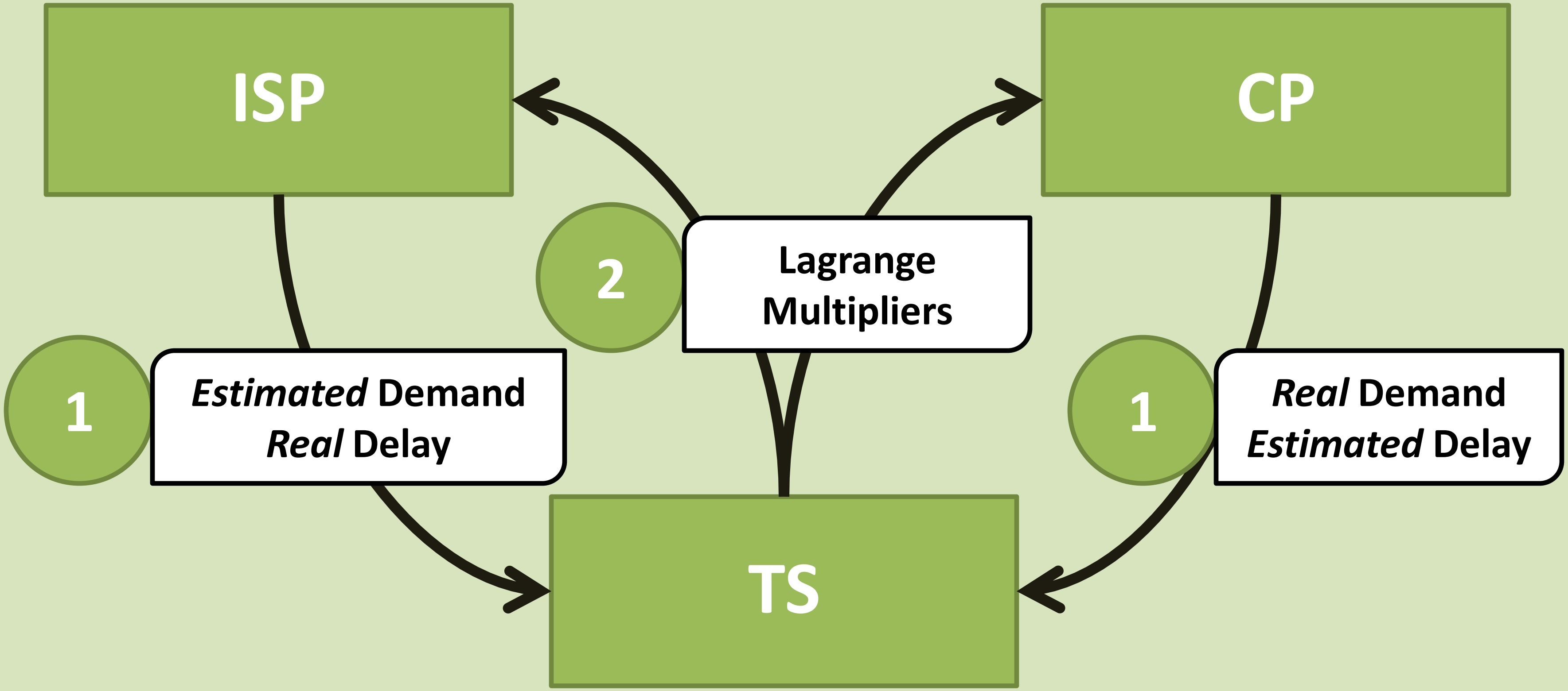
Next Steps

- Distributed Algorithms to limit the shared information
- Cooperation of multiple CPs
- Impact of virtualization and colocation of servers

Questions?

A Dual Decomposition Approach

- GreenCoop can be split between the ISP and the CP
- Iteration until convergence
- Implementation requires a Trusted Server (TS)



Discussion

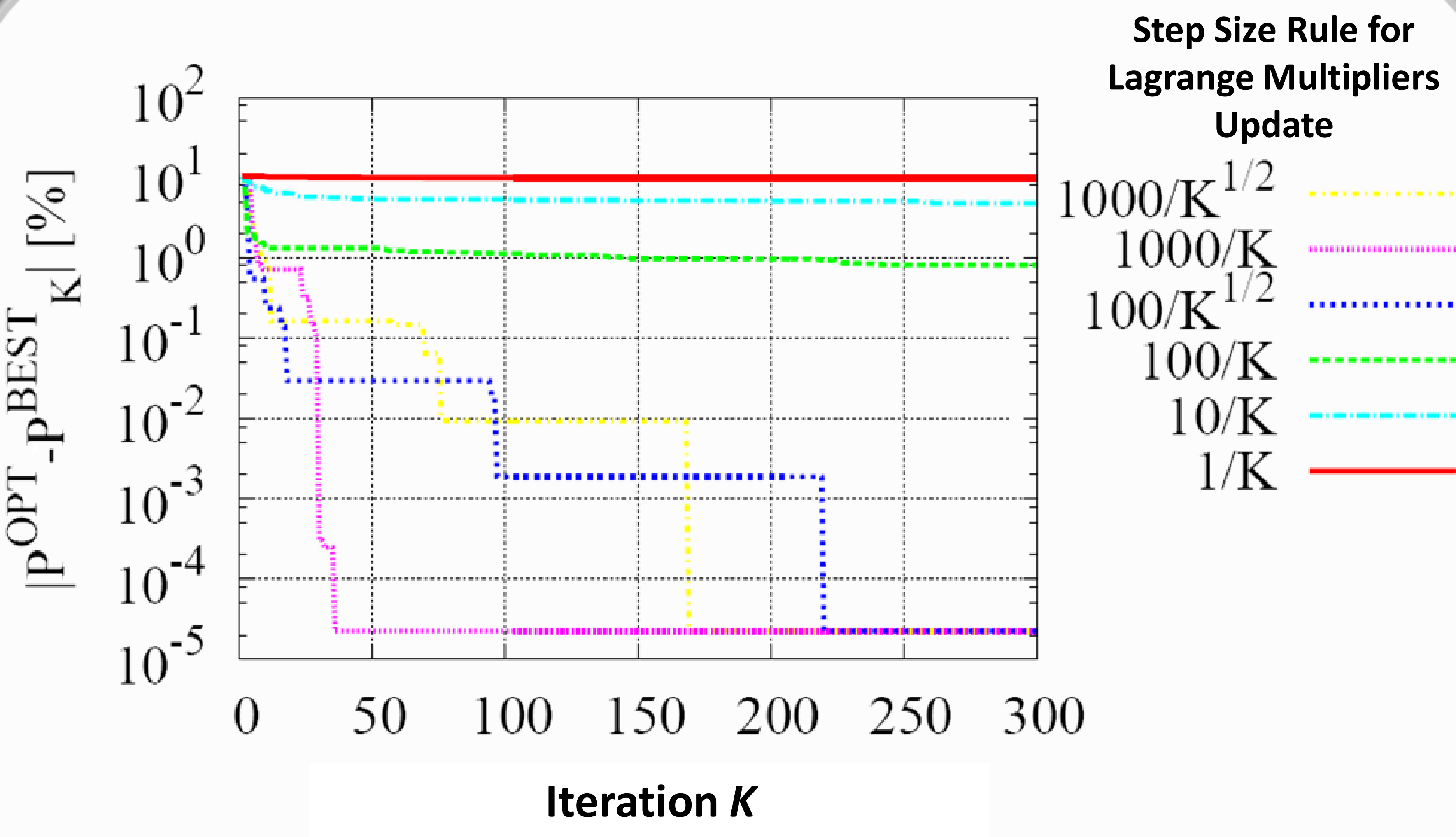
Advantages

- the CP does NOT know: ISP topology, link capacity, power consumption of ISP devices, routes for traffic demand
- the ISP does NOT know: server load, server capacity, CP power consumption
- The distributed problems are smaller than GreenCoop and can be solved in parallel

Ongoing Work

- Impact of Lagrange Multipliers on convergence time
- Optimal solution guaranteed for convex power functions.

Parameters Tuning



Thank you!