Energy Efficient Content Distribution

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IEEE International Conference on Communications
June 11, 2013

COATI Project

I3S(CNRS/UNS)–INRIA, PACA, France

Energy Efficient Content Distribution

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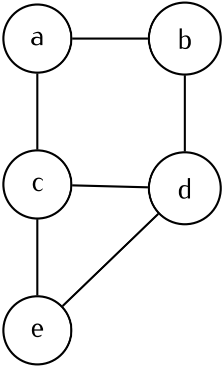
Energy to be saved:

- Networks are over-provisioned for rush hour
- Huge daily variations in traffic
- Video over Internet is growing

Problem description

Minimize energy consumption by putting devices to sleep

- Aggregated demands
- CDN demands
- Content caches



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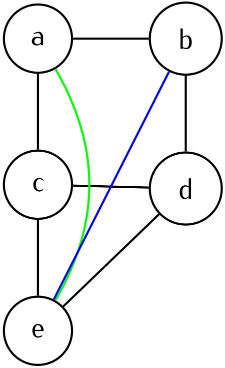

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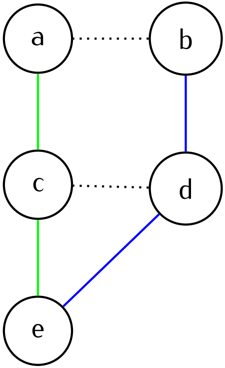

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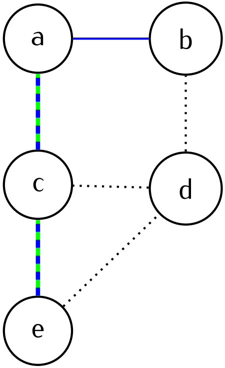

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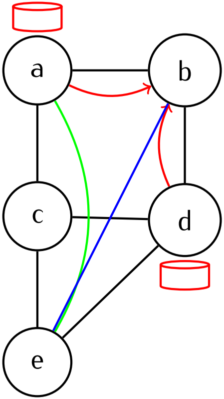

Energy-Aware Network Management and Content Distribution by Chiaraviglio and Matta

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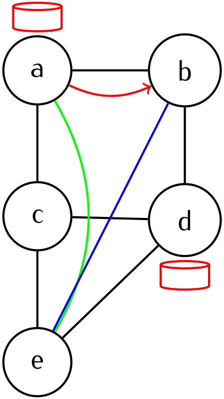

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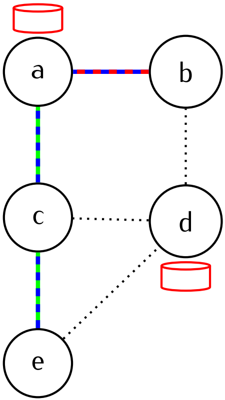

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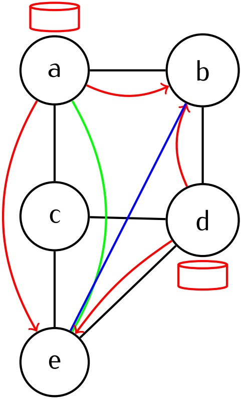

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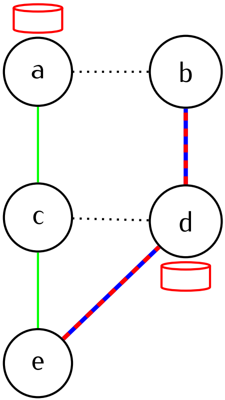

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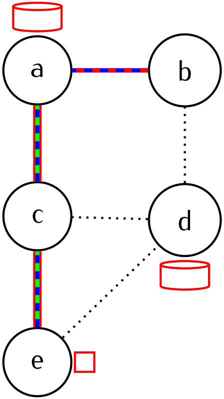
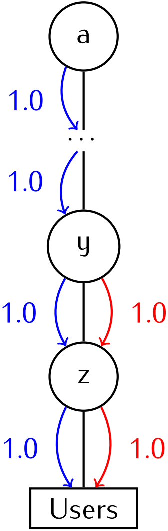


Problem description – caches

- Caches located at routers
- Can be on/off, consume energy
- Serve only local clients
- Can be selective in what to cache



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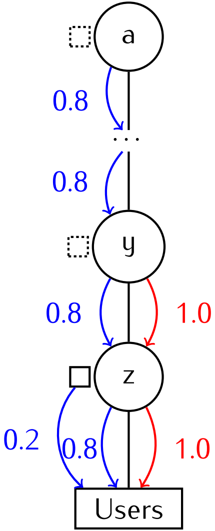


Mixed Integer Linear Program

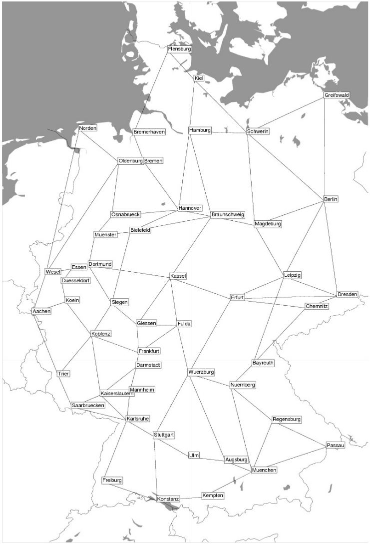
Solution: Mixed Integer Linear Program

- Minimize total energy, find feasible routing
- $O(n^3)$ constraints
- Solved directly, with time limits
- Extended version: polynomial-time rounding heuristic

Despite fractional routing, problem **NP-complete**

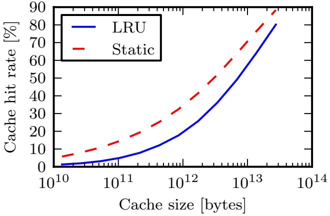
Instance generation

- Network topologies from SNDlib
- Some instances have labeled cities
- Demands based on metropolitan area populations
- Content providers inspired by market leaders
- Server locations based on known Internet eXchange points



Cache parameters

- Cache **hit ratio** depends on cache and collection sizes (not on access rate) $\alpha \in [0.2, 0.35]$ [1]
- **Energy usage**: links are line cards and amplifiers, caches are SSD-based $\beta \in [0.1, 1], \gamma \in [0.3, 1]$ [2]

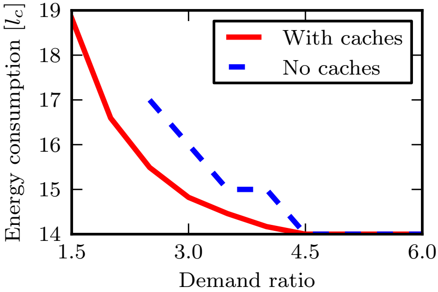


Cache hit ratio for YouTube trace, assuming average video size 100MB.

[1] Haßlinger and Hohlfeld, "Efficiency of caches for content distribution on the internet", ITC 2010

[2] Powerlib, manufacturer data sheets

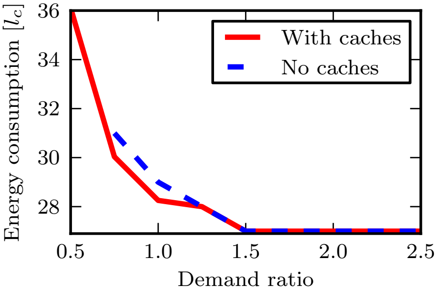
Off-peak savings



⇐ high traffic   low traffic ⇒

Atlanta: 15 nodes, 22 edges, 21.3% savings, max 8.9% by caches

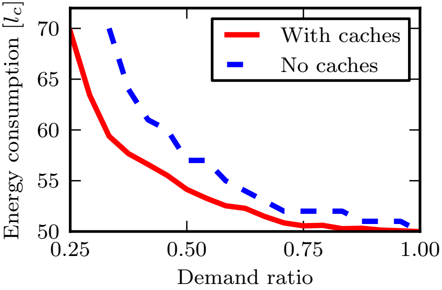
Off-peak savings



⇐ high traffic low traffic ⇒

Nobel-EU: 28 nodes, 41 edges, 21.7% savings, max 3.9% by caches

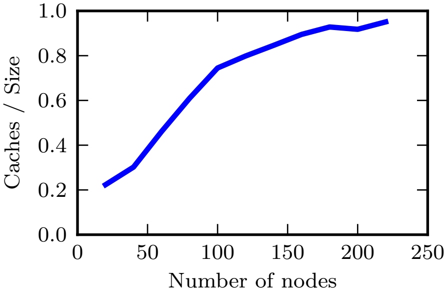
Off-peak savings



⇐ high traffic low traffic ⇒

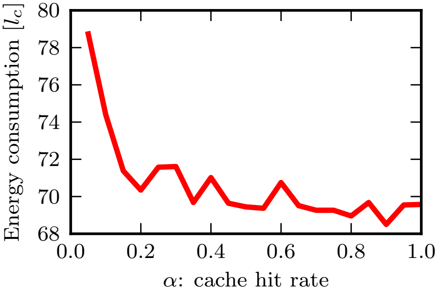
Germany: 50 nodes, 88 edges, 22.3% savings, max 16.7% by caches

Impact of network size



Impact grows with the network size

Big or small caches?



Plateau over 20% hit rate
About 1TB according to Haßlinger and Hohlfeld's study

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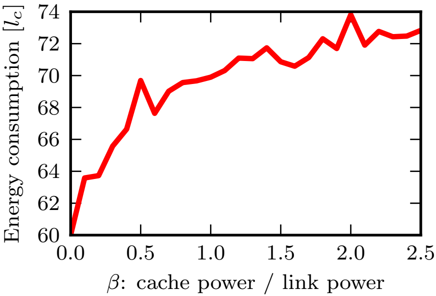

Choose a module with power consumption below 50% of link's

Conclusions

- Over 20% energy saved by off-peak sleep mode
- Caches allow more traffic
- Caches allow savings with some given traffic levels
- Better to have small caches that use less energy
- Caches are more important in bigger networks

Questions