Measuring the energy cost of networking intensive applications

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SEVENTH FRAMEWORK PROGRAMME

Introduction (1/3)

- The rapid growth of the Internet brings new challenges for the management and distribution of content to users.

- Initially, the used systems were based on the client-server architecture, i.e. Web services which use the HTTP protocol.

- Content Delivery Networks (CDN) and peer-to-peer file sharing networks, were developed to address the performance problem in order to improve the Quality of Service (QoS).

Introduction (2/3)

- These content delivery mechanisms have the same role of distributing content to the end-users.

- In order to meet the demands of faster and more reliable Internet applications and services, the number of network devices had to increase enormously.

- From estimations is noted that the ICT sector consumes between 2% and 10% of the worldwide energy consumption, and these values are expected to increase in the future years, if no radical changes in Internet technology design will be undertaken.

- This figure becomes even more impressive if we consider not only networking devices (e.g., routers, switches, etc) inside telecom and home networks, but also the “networked” ones

Introduction (3/3)

- Previous works showed that the CPU is one of key components with higher power consumption.

- The workload of a CPU arises from the applications that are running on it, and on the activities performed at the kernel level to support them.

- CPU's already implement advanced power management features, which can be set through the Advanced Configuration and Power Interface (ACPI).

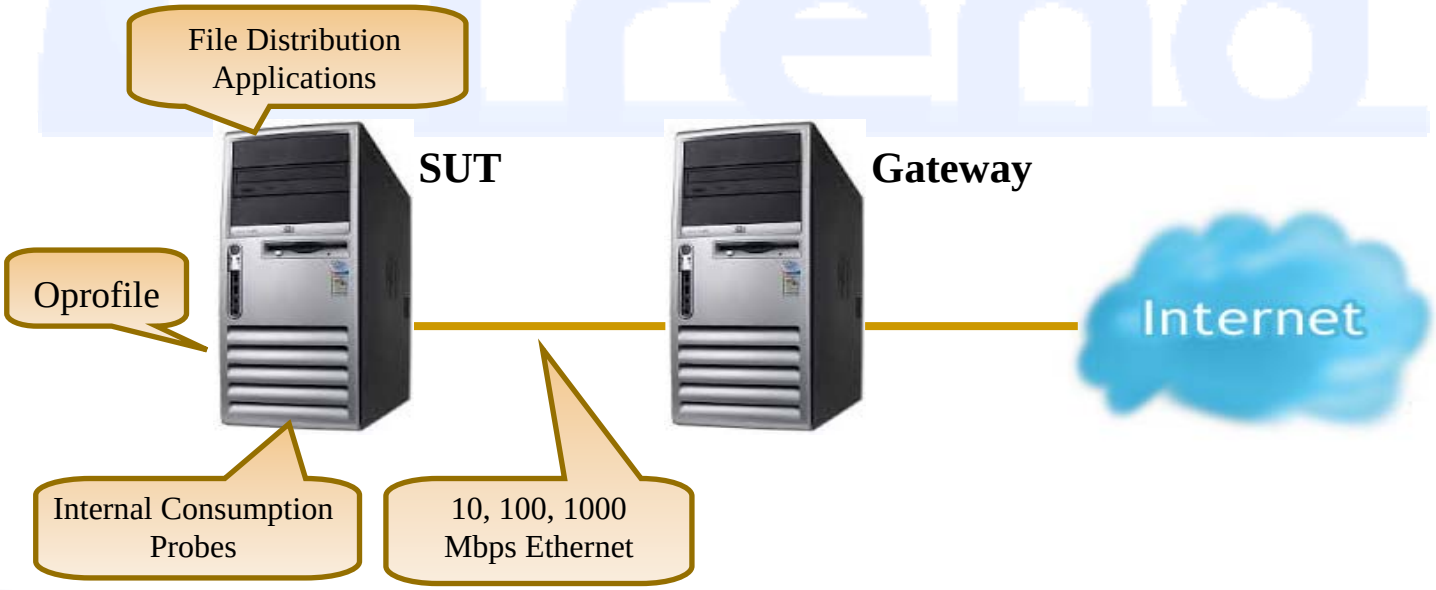
Objectives

- To provide an in-depth experimental analysis of the impact of some distribution systems on the energy behavior of a final user networked device.

- To evaluate how the network conditions affect the performance of these distribution systems.

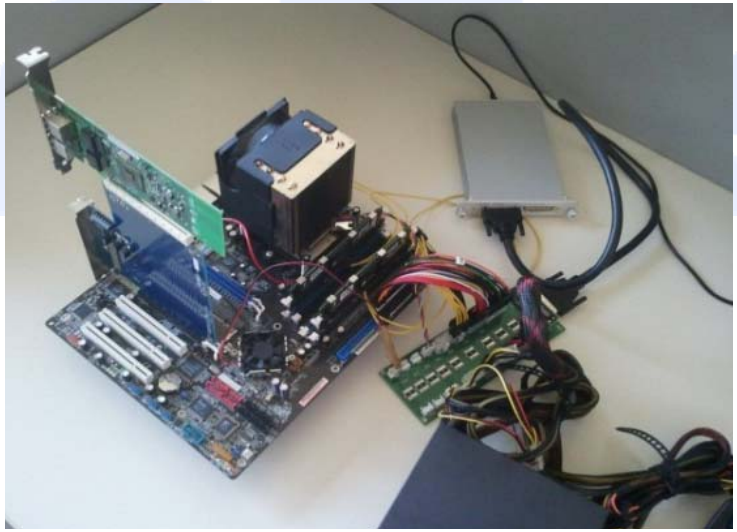
Experimental Testbed

- *System Under Test (SUT):* a commercial off-the-shelf PC, based on the Intel i5 processor, and running the Debian Linux operating system.
- *A PC Linux based:* used as a Gateway
- *A multi-channel Data AcQuisition (DAQ)*: used to collect a high number of DC power consumption probes.



Internal Consumption Probes

- We used a riser board for ATX power connectors which allows putting some current and voltage probes on the CPU supply rails. The probe outputs are collected by an external DAQ.



Designed and developed within ECONET project

Internal Measurements

- Internal SW probes
  - Oprofile
    - allows the effective evaluation of the CPU utilization of both Linux user- and kernel-space with a very low computational overhead
- Network Performance Probes
  - Tcpdump
    - to evaluate network performance indexes

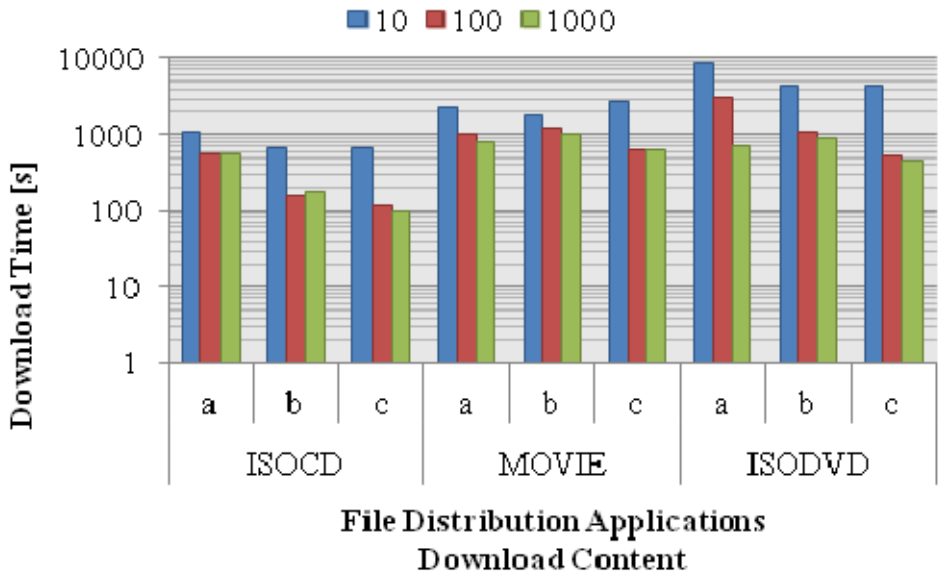
Testing scenario

- In order to evaluate the energy cost of different downloading contents we decided to perform the tests using three different file distribution applications:
  - a) HTTP, the typical client-server approach,
  - b) Vuze, a user-friendly graphical interface BitTorrent client
  - c) Transmission, a command-line BitTorrent client.

BOTTLENECK BANDWIDTH [MBPS]	*DOWNLOAD*	*SIZE*
1000 - 100 - 10	Debian-6.0.7-amd64-CD-1.iso	676 MB
	Debian-6.0.5-amd64-DVD-1.iso	4.64 GB
	Parker.avi (Film)	2.5 GB

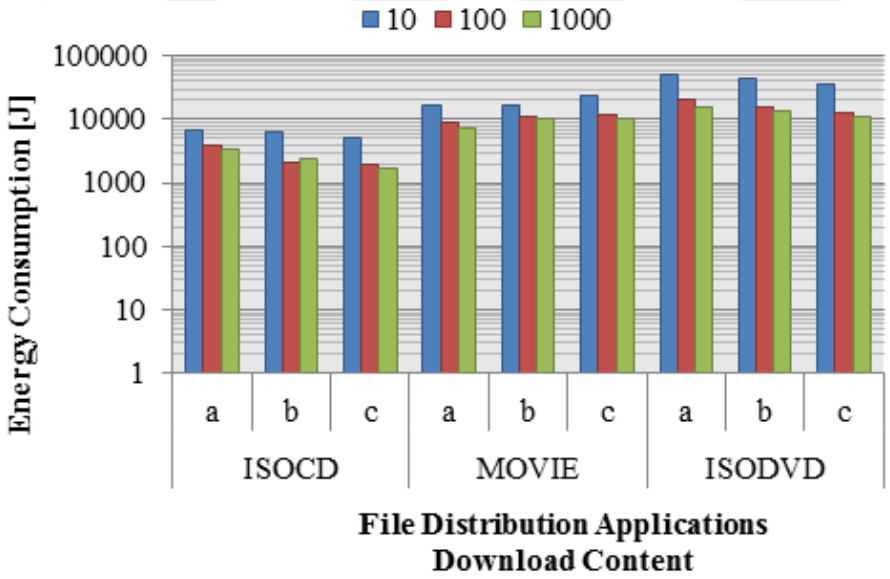
Experimental results (1/4)

- Network Performance
  - The amount of data downloaded and the speed link impact the download time.
  - HTTP needs more time than Vuze and Transmission to download the same amount of data, due to the fact that HTTP uses a single source instead of the multiple sources exploited by BitTorrent applications.



Experimental results (2/4)

- Energy consumption
  - In presence of lower bottleneck speeds the energy consumption increases in a significant way.
  - The energy consumption is influenced by the downloading time, resulting in higher energy requirements by the HTTP protocol in the case of collaborative downloads.
  - Energy savings between 10% and 50%.
  - In the movie case, the energy consumption with BitTorrent applications is higher than HTTP (15% - 25%). This behavior could depend on the available bandwidth shared by the peers and on the number and type of such peer connections.



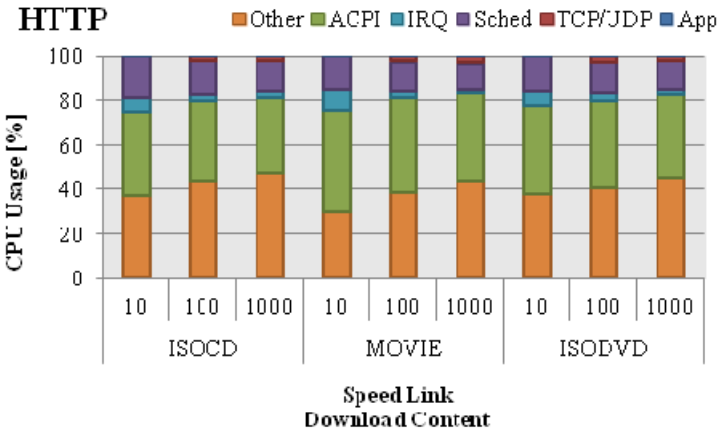
Experimental results (3/4)

- Profiling CPU SW activities
  - Oprofile to understand insights of the computational complexity of SUT SW components

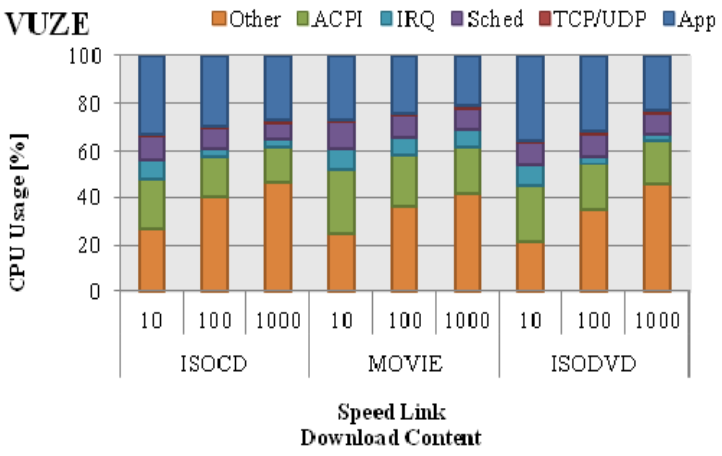
Name	Description
App	File Distribution Applications
TCP/UDP	traffic processing at the TCP and UDP layer
ACPI	the ACPI and especially the functions related to idle-active transitions and vice versa
Sched	the operating system scheduler
IRQ	management of HW interrupts, mainly due to the NIC.
Other	other spurious sources of CPU activity

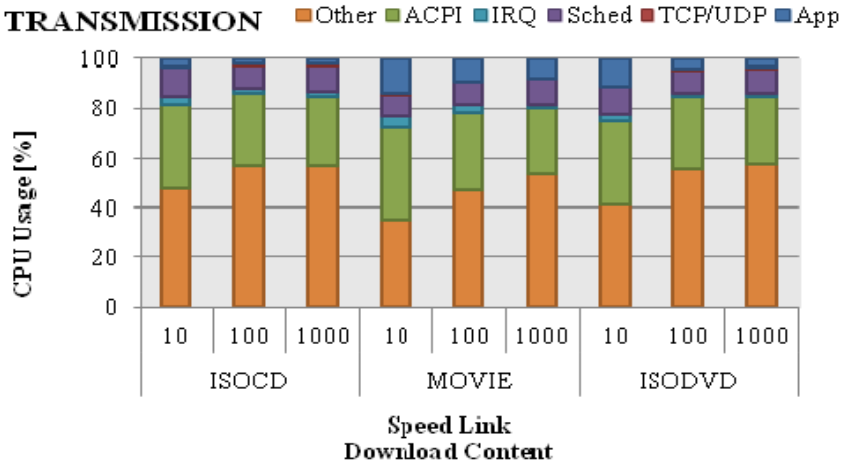
OPROFILE FUNCTION CATEGORIES FOR THE ENTIRE SUT SW

Experimental results (4/4)



- The App category in the HTTP case is almost imperceptible (up to 0.28%). Instead of BT applications where the App category account for 20% - 35% of the CPU activity time with Vuze, and between 2% and 15% with Transmission.
- The TCP/UDP category appears to not significantly affect the CPU Uptime, up to 3% with HTTP, and less than 1% in Vuze and Transmission cases.
- The OS scheduler accounts for 12% - 18% in HTTP, and between 8% and 12% in Vuze and Transmission cases. These values seem to be dependent on the HW interrupts, (2% - 6% in HTTP, 3% - 9% in Vuze, and 2% - 5% in Transmission).
- The scheduler job executes ACPI functions, which in HTTP case range between 34% and 45% of the CPU uptime, 15% - 23% in Vuze cases, and 26% - 37% in Transmission cases.





Conclusion

- The network conditions affect the performance of the file distribution applications. Lower bottlenecks increase the download time.

- In presence of lower bottleneck speeds the energy consumption increases in a significant way.

- The CPU activity time also affects the energy consumption of the different applications. In the Movie case the high dynamics of the sharing peers (peers arrive and leave the swarm over time) affect the CPU behavior, consuming more than HTTP.

THANK YOU

QUESTIONS?