Technologie

EcoCloud: innovating, economical and environment-friendly ICT

Cloud computing promises to bring ubiquitous information access with virtually-unbounded resources to all users at home, at work or on the move alike. The computing servers forming the backbone of information technology, however, have hit an energy "wall" with unsurmountable costs and environmental implications. EcoCloud, a research center at EPFL, is pioneering technologies to make computing cost-effective and sustainable.

By Babak Falsafi, Director, EcoCloud, EPFL Professor, Computer & Communication Sciences, 19 january 2011

Today, we live in a digital world. Our daily needs are unthinkable without access to information. Communication, entertainment, social networking, and financial, transportation and health services are just a few examples of how our day-to-day interactions have transformed into data exchanges in the form of a stream of bits. Information technology, now ever more than before, is a necessity rather than a luxury to our existence and proper functioning as a citizen of the modern world.

At the center of this revolution is data. As individuals we need ubiquitous access, exchange and sharing of data with those we interact with. Similarly, businesses, governments and societies rely on collecting, analyzing and exchanging data to improve their products, services and ultimately enhance our lives. Cloud computing is emerging as a novel paradigm that enables this novel information revolution.

In the common form, cloud computing appears to users as a service (much like electricity, water and phone at home). A large collection of computing servers, referred to as a datacenter, store and process the information provided as a computing service. Users can access the services through a network connection to their smartphones, home electronics or computers at work. These services can be private and available internally to a particular organization or company, or can be public much like a utility. The services may take on a variety of forms at a given quality level (e.g., speed, capacity, reliability) and price targeting a wide range of audiences.

A new information revolution

While cloud computing emerges as the new information revolution, it is also facing a number of technological, economic and societal challenges. A key challenge that threatens to sabotage cloud computing from realizing its full potential is energy. Today, a medium-scale datacenter of 5,000 m2 requires about 15 MW of electricity, equal to half a dozen wind turbines to feed it. According to reports from Energy Star and various think-tanks in the US, today's servers and datacenters use the same aggregate energy as television and display sets in all households and have the same carbon footprint as the airline industry. While these are a few percentage points of the overall electricity usage and carbon emissions, the economic burden is substantial for smaller enterprises, leaving them with no option but to buy computing as a service. Moreover, the energy usage trends for computing, unlike other industries, if not mitigated are potentially exponential thereby slowing the growth of cloud computing.

The miraculous growth in computing since the inception of microprocessors in the 70's has been due to an exponential increase in chip density (the number of computational and storage elements packed per chip), doubling the capability of a semiconductor chip for the same cost every two years. This improvement in density was accompanied by commensurate reductions in chip electrical activity requiring only minimal to modest increases in energy.

Chip voltages hit a wall

Traditionally, designers reduced the electrical voltage levels with every new chip generation. Doing so allowed for doubling the computational and storage capability at roughly the same overall chip energy. While projections for chip fabrication indicate a continued increase in chip density for another decade, the conventional approach to limiting electrical activity has reached diminishing returns. Chip voltages have reached a level below which it is not feasible to operate the chip reliably and reduce energy. Therefore, while density grows, there is a need for technologies to drastically cut the energy in processing and storing information.

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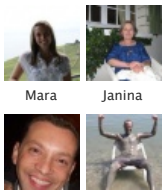

Similarly, to function properly, servers and datacenters must be housed and operated below a certain temperature. Therefore a substantial fraction of the overall electricity usage is consumed in air conditioning. With energy consumptions rising in the future chips, there is also a need for technologies that drastically improve cooling requirements and efficiency in future computing platforms. Moreover, these technologies must work hand in hand with information processing and storage to enable energy proportionality, that is use energy proportional to performance and cooling on demand based on a negotiated service level and price.

Prof. Babak Falsafi and colleagues at EPFL are establishing the EcoCloud research center to pioneer information processing and storage technologies and enable energy proportionality (and eventual sustainability) in cloud computing. The research targets technologies to minimize energy consumption in operating and cooling servers to process and store information while providing ubiquitous access for frequently used cloud services.

Dark silicon

A key research thrust in EcoCloud is system design and operation for minimal energy. Future chips designs are likely going to be built on “dark silicon” where a continued increase in chip density with a limited energy budget results in activating only a portion of the chip at a time, while leaving the rest without electricity (or “dark”). Dark silicon pushes innovations towards specialization where a single chip will include a spectrum of hardware accelerators to access and manipulate data in the cloud workloads with minimal energy. Data access also requires effective connectivity and storage. Future datacenter chips are likely to provide direct connectivity between (conventionally-separate) processing cores and memory into single 3D-stacked chip (above) to allow for effective data access.

A substantial fraction of cloud energy is dissipated in cooling servers. Conventional air-cooling has reached diminishing returns in efficiency and effectiveness. EcoCloud researchers are also pioneering cost-effective liquid cooling technologies in 3D-stacked chips. Unlike air-cooling, liquid-cooled chips include internal flow channels for heat removal across the multiple chip layers. Liquid cooling has drastically improved heat removal effectiveness and can allow operation at higher temperature with high reliability and less electricity consumed for cooling.

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