From Ambient Intelligence To Silicon Process Technology

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As a result of the ongoing miniaturization of electronic circuits and the corresponding exponential increase in embedded computational power, we are reaching the point where it becomes viable to integrate electronics into people environments. Ambient Intelligence refers to an electronic environment that is sensitive and responsive to the presence of people. Such an environment should be

- ubiquitous: surrounding the user by a multitude of interconnected systems
- transparent: integrated and "hidden" into the background
- intelligent: adapting to the people that live in it

This paper makes an attempt at translating these high level needs into demands for Silicon process technology.

Upon considering these demands, it appears helpful to further classify in-home Ambient Intelligence "devices"

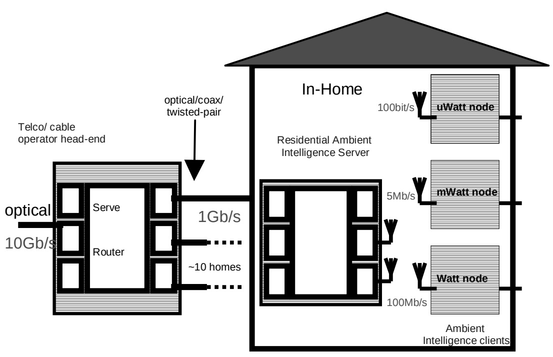

Figure 1: In Home AI nodes

into three distinct classes, as illustrated in figure 1.

- The "watt-node", taking care of the major computational intensive tasks, e.g. 3D TV at high data rate, networked games etc
- The "milli-watt-node", representing low power processing, Computational Efficient, mobile, personal and connected (audio/video) devices in the home
- The "micro-watt-node", representing a multitude of "electronic dust" devices that perform environmental tasks like sensing, identification , positioning, etc

It is envisaged that each of the three classes represents about equivalent "in-home" Si-area.

For the "watt-node", getting its supply from mains, raw computational power , from few to GOPS, is required and potentially supplied for by the rapid Moore's law CMOS scaling trend. For this class of devices, the major challenges in Si process technology can be traced back to the red-brick wall scaling limits, timely introduction of added options like memories and RF, and – more severely- , the strong upward trend in the cost of Silicon (figure 2) as well as in the rising cost of "re-use" and Software implementations.

For the "milliwatt and microwatt" nodes, power efficiency is governing most of the challenges. The trade-off is here between more flexible programmable platform

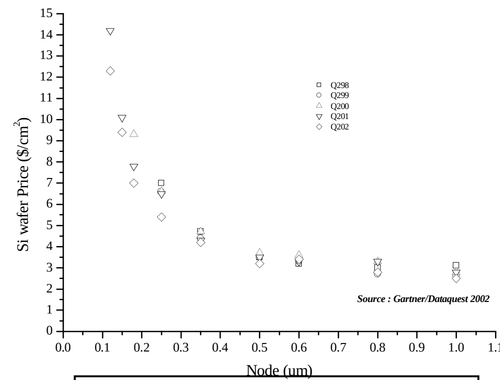

Fig 2: Si Area Price trend vs node

concepts vs hard-wired ASIC solutions i.e. a tradeoff on Intrinsic Computational Power of Silicon. For the "milliwatt" nodes the translation in Si-demands involve wireless applications from few bits/s to Gb/s and concern RF integration, passives, multi-die, high ft BiCMOS, embedded memories… It can be argued that one can expect a trend towards smart combinations that

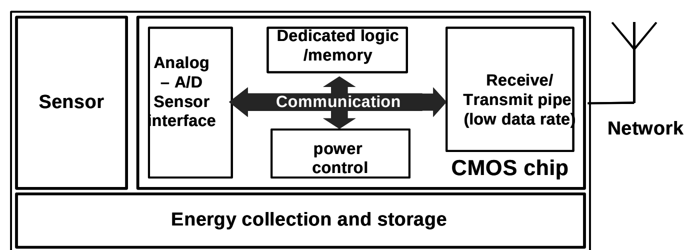

Fig 3: Architecture of a Smart Dust Device

represent optimal partitioning of the available process technology choices , like CMOS, RF, Passive Integration into "systems in a package".

Whereas for the milli-watt node, rechargeable batteries are still an option, for Electronic Dust devices, it is expected that they in principle should be self-supplying, i.e. during the lifetime of the device, no new power supply can be expected to be available. Thus, very low off state leakage, duty cycle management and embedded dense capacitors for power handling are requested aspects. Moreover, from its architecture, (fig 3) it can be concluded that the wireless communication portion that forms an obliged part of such devices determines to a large extent its power consumption. From simple estimates of the power needs of these devices, in comparison with the available power from small volume rechargeable batteries and/or energy scavenging methodologies it is concluded that still major obstacles remain to be solved before such devices can be implemented. In addition, sensing, MEMS and energy scavenging will need to be integrated in a single and very small package.

In conclusion, it is clear that the field is abundant in challenges in each of the three "power" nodes. It is expected that the introduction of Ambient Intelligence Devices will thus be "gradual" and its rate of introduction be strongly dependent on the necessary technology advances that remain to be solved.