Lecture 2

Mobile devices energy management

Software aspects

- The *kernel power policy manager* (kernel process) owns the decision-making and the set of rules used to determine the appropriate frequency/voltage operating state. It may make decisions based on several inputs, such as end-user power policy, processor utilization, battery level, or thermal conditions and events.

- Example: the processor driver is used to make actual state transitions on the kernel power policy manager's behalf.

- All architectural units are designed to save energy.

A. Memory energy saving

- Intel FBC (Frame Buffer Compression) works by *compressing* the amount of memory used by the display.
- FBC has the ability to reduce power consumption for those using Intel HD Graphics while reducing the amount of memory bandwidth used for screen refreshes.

- While the processor is in lower power states, memory will automatically be refreshed without relying on the processor or processor graphics core to enter higher power states to refresh the memory. Since memory is basically a capacitor it must be refreshed, or the charge renewed, in order to continue to store the data.

B. Display and graphics energy saving

- The display is placed in a slower refresh rate.
- Based upon inputs from the ambient light sensor, the graphics driver will automatically adjust the display to provide the best user experience – adapt the brightness.
- Lower the frequency and power.

C. Power equation

$$\text{Power} = F * V^2 * C + \text{Leakage}$$

where, F = frequency,

V= voltage,

C = capacitance

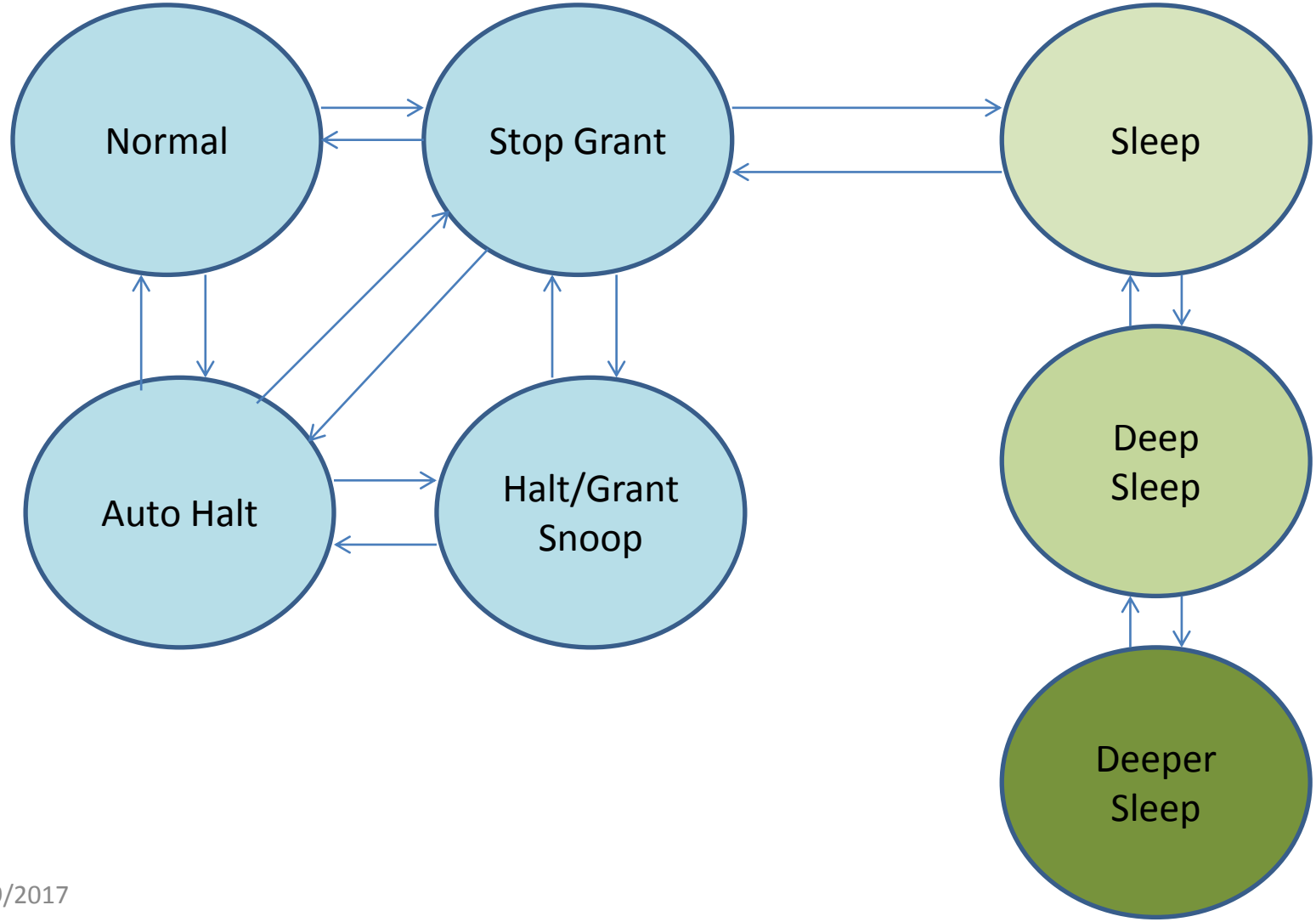
- Voltage importance: cutting voltage in half from two volts to one volt will have the result of decreasing the power by 300%, to a quarter of the previous power.

CPU energy management

- For example, Enhanced Intel SpeedStep Technology enables real-time dynamic switching between multiple voltage and frequency points. It provides significantly improved power to performance and energy control scheme. This is accomplished via application software, which changes the bus-to-core frequency ratio and the processor core voltage (Vcc).

- *A variety of inputs such as system power source, processor thermal state, or operating system policy are used to determine the proper operating state.*

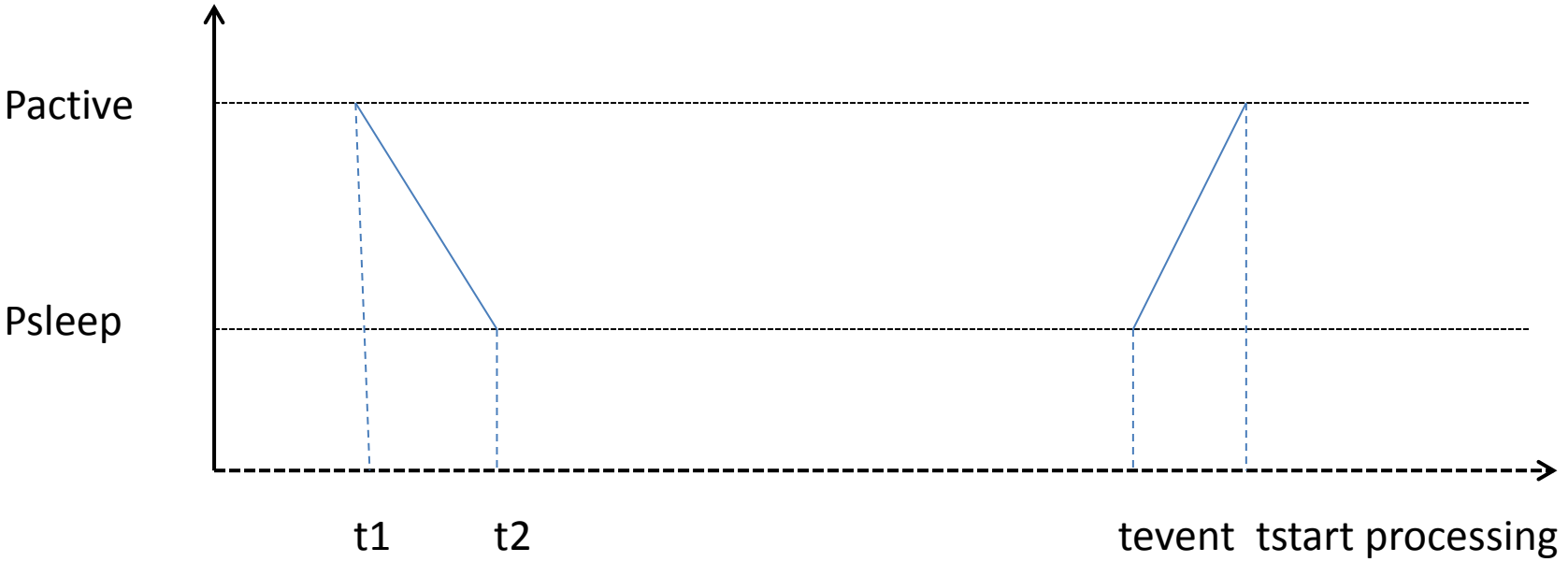
Intel Pentium M CPU states



Multiple states with different energy consumption

- Using multiple states of operation with reduced energy consumption is the basic mechanism for saving energy – the term Dynamic Power Management refers to this area of work.
- Multiple states can be introduced to all components of a mobile device, e.g., CPU, memory, transceiver, display etc.
- However, transitions between states take time and energy…
- "The deeper the sleep time, the more energy and time it takes to wake up to fully operational state."

Energy saving and overhead for sleep modes



- Esaved = (tstart processing – t1)Pactive - (t2 – t1)(Pactive + Psleep)/2 – (tevent – t2) Psleep - (tstart processing – tevent)(Pactive + Psleep)/2
- Eoverhead = (tstart processing – tevent)(Pactive + Psleep)/2

Links

- http://www.intel.com/content/dam/doc/white-paper/power-management-technologies-for-processor-graphics-display-and-memory-paper.pdf
- http://download.intel.com/design/network/papers/30117401.pdf
- http://download.intel.com/support/processors/mobile/pm/sb/30218908.pdf