$C(\alpha, \text{instr type}) \rightarrow$ consider avg

1. $t = \underbrace{C N_i}_{\text{busy}} + t_{idle}$

$N_i \rightarrow$ instructions

$t_{idle} \rightarrow$ idle time, possibly 0

idle $\rightarrow$ opp. idle

opportunity

freq, $f = \frac{\text{cycles}}{\text{time}}$

$t = \frac{A N_i}{f^{1+\alpha}} + t_{idle}$ $\rightarrow$ depends on arrival rate

$f^{1+\alpha} \rightarrow \Delta^{1+\alpha}$

$1+\alpha \rightarrow$ deviation from simple theory

More precisely: if arrival rate λ,

[non-stochastic analysis] $\delta t = \frac{1}{\lambda}$

$\delta t \rightarrow$ time between arrivals

$$t_{idle} = [\underbrace{\delta t}_{\text{time between arrivals}} - t_{busy}]^+ = \left[\frac{1}{\lambda} - t_{busy}\right]^+$$

$$= \left[\frac{1}{\lambda} - \frac{A N_i}{f^{1+\alpha}}\right]^+$$

2. Energy, $E = P_{busy} t_{busy} + \underbrace{P_{idle} t_{idle}}_{\text{can break into sleep/non-sleep}}$

t_{busy} " $\leq$ ref cycles

$= B V^2 f \; t_{busy} + P_{idle} t_{idle}$

$f \rightarrow$ function (dvfs $= \Delta$)

$V \rightarrow$ function (dvfs $= \Delta$)

$f \rightarrow \Delta^a$?

$V \rightarrow \Delta^b$

$V^2 f \rightarrow \Delta^{2+\beta}$

(*) Energy, $E = B\,\delta^{2+\beta} \dfrac{A N_i}{\delta^{1+\alpha}} + P_{idle}\, t_{idle}$

$$= A B N_i\, \delta^{1+\beta-\alpha} + P_{idle}\left[\frac{1}{\lambda} - \frac{A N_i}{\delta^{1+\alpha}}\right]^+$$

Assumption: $t_{idle} \to t_{idle} + \tau(i/o)$ ↳ doesn't account for packet bunching

$\tau < 1/\lambda$ (correct)

$\tau > \frac{1}{\lambda}$ bunching (not accounted for)

3. $t_{busy} = \dfrac{A N_i}{\delta^{1+\alpha}}$

$$\Rightarrow \quad \delta = \left(\frac{A N_i}{t_{busy}}\right)^{1/1+\alpha}$$

$$E = A B N_i \left[\frac{A N_i}{t_{busy}}\right]^{\frac{(1+\beta-\alpha)}{1+\alpha}} + P_{idle}\left[\frac{1}{\lambda} - t_{busy}\right]^+$$

(Case I)

$t_{idle} > 0$: $E = A B N_i$