Thermal Design of Consumer Electronics

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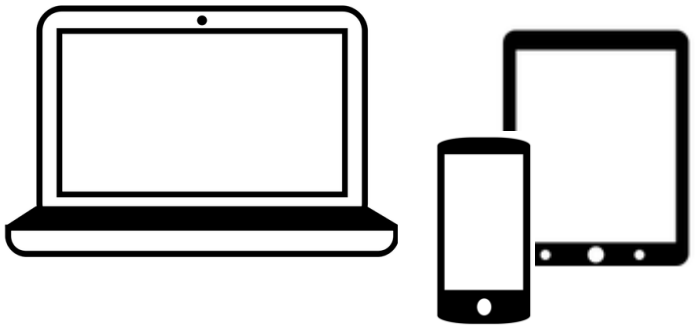
Agenda

- Proliferation of consumer electronics
- Performance Vs Power
- How to improve performance
- Challenges in Consumer Electronics Thermal Design
- Takeaways

Proliferation of Consumer Electronics

- Consumer Electronics (CE) CAGR ~ 5% for the next decade
- Expected to be a trillion-dollar industry by 2030
- Drivers of growth
  - Innovation
  - Reliance for every-day activities
  - Increasing disposable income levels
  - Some CE devices synonymous with luxury
- Technology → Performance is a key differentiating factor



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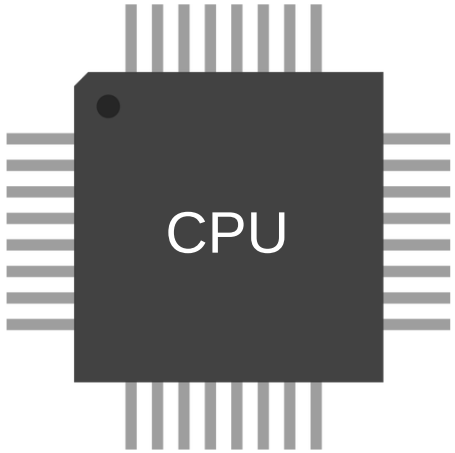
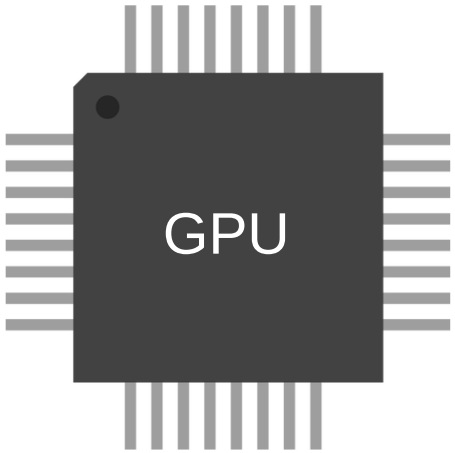
Research : precedenceresearch.com

Higher Performance → Higher Power → Higher Heat



1. Frequency 2. Utilization

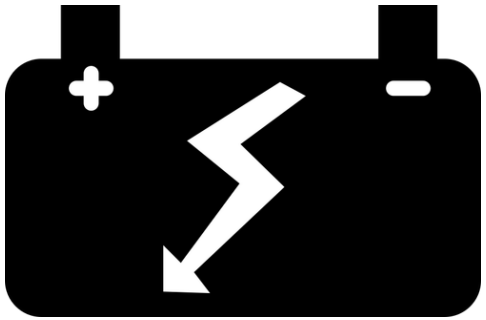


1. Frequency / Frame Rate

1. Resolution 2. Refresh rate 3. Brightness

1. Frames per second

1. Volume 2. Content



1. Discharge rate 2. State of charge

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How do we improve performance ?

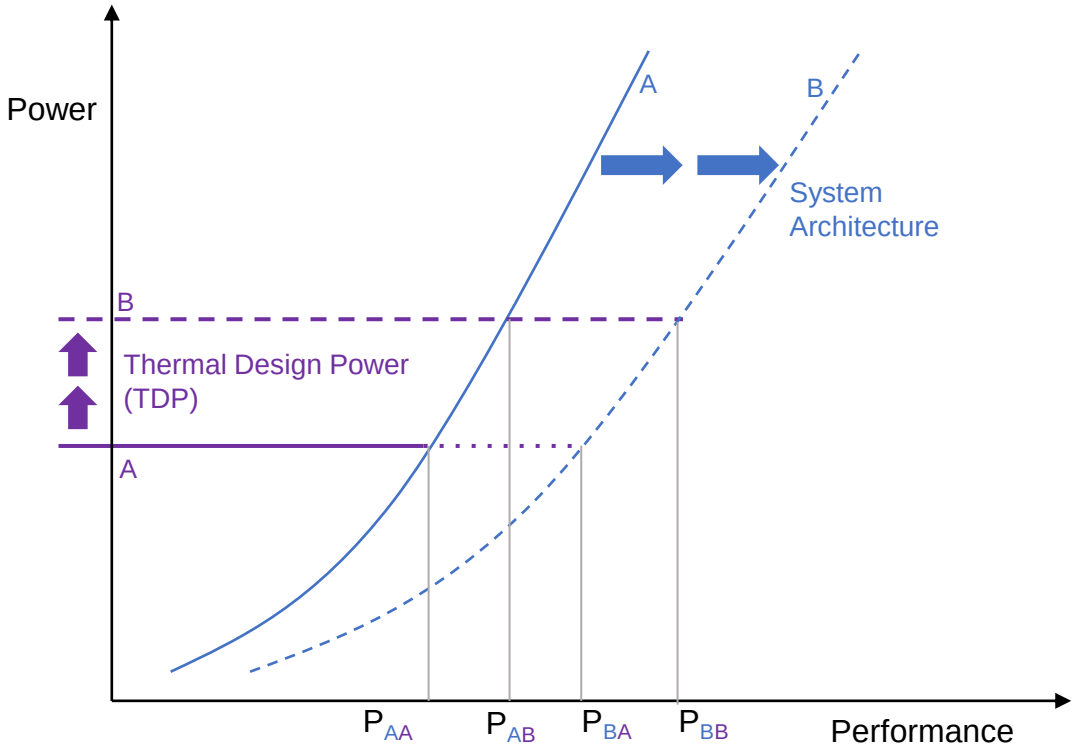
Option 1 [P_{BA}] - Better system architecture

- Next generation SoCs, big.LITTLE CPU architecture etc.
- Higher efficiency (perf/watt) components

Option 2 [P_{AB}] - Better thermal design → Higher TDP

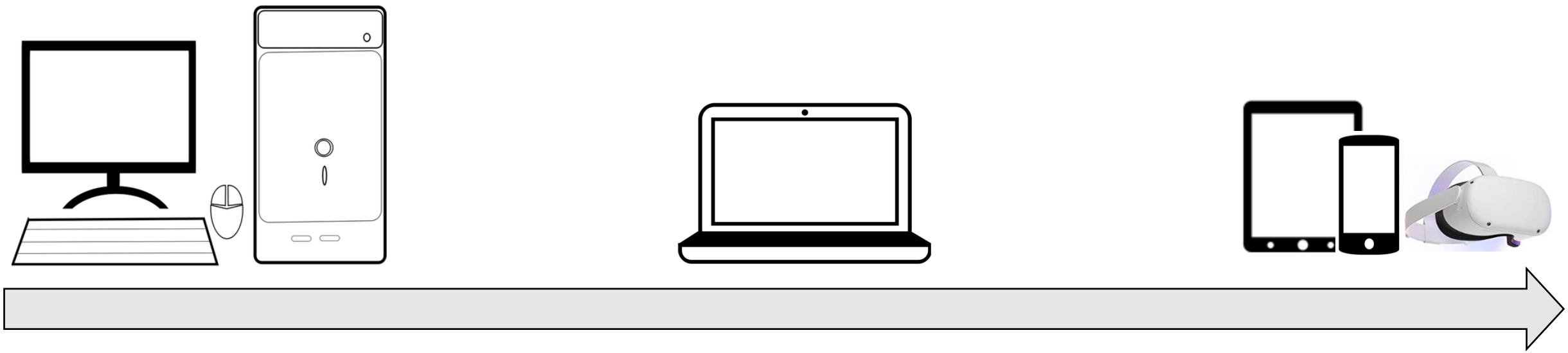
- Better heat-spreading
- Active cooling

Option 3 [P_{BB}] - Options 1 & 2



Challenges in Consumer Electronics Thermal Design

Miniaturization



- Enough space for multiple axial fans and heat-sinks.
- Closed loop liquid cooling
- Weight and ergonomics not a concern
- Touch limits not a concern
- Usage conditions → air-conditioned room

- Heat-sinks → Heat-pipe + fin-array
- Space permits only high-pressure low volume blowers
- Low weight is desirable
- Touch limits on palm rest
- More variable usage conditions

- Either passive cooling or small fans
- Small heat-pipe or spreader
- Low weight is desirable
- Small motherboards → PoP packages → high power density → local surface hotspots
- Varied usage conditions – indoors/outdoors.

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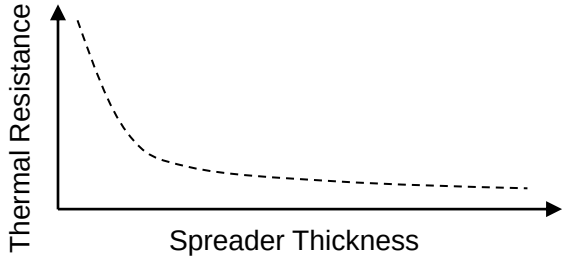
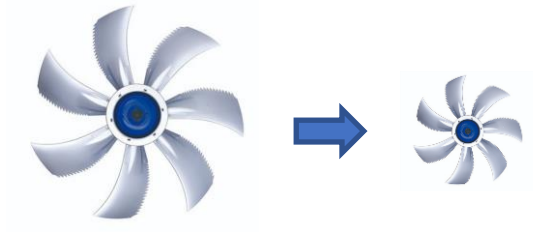
User Experience

Weight/Ergo

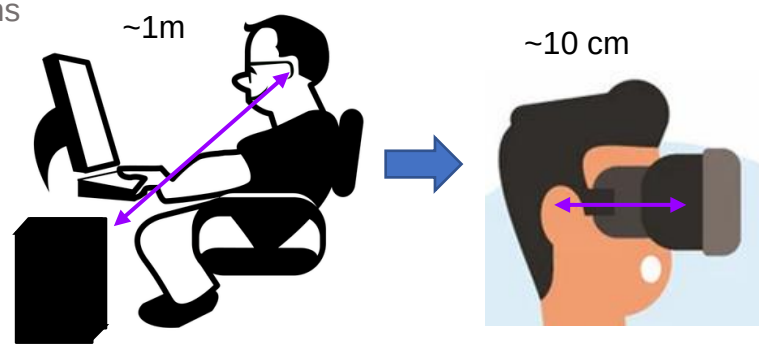
- Thinner heat-spreaders
- Higher thermal resistance
- Lighter/less metal → Inferior thermal conductivity
  Cu > Al > Mag
- Smaller fans → smaller flow





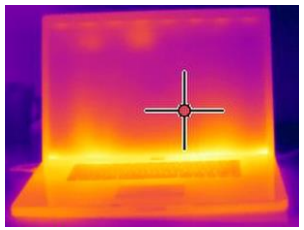
Acoustics

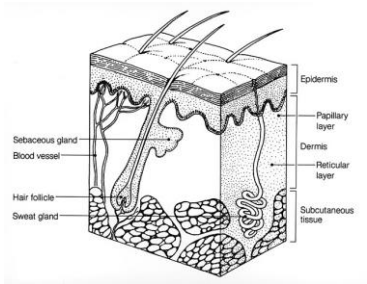
- Small(er) sizes → Smaller Fans
- Shrinking distance b/w user and device lowers operating RPM further.



Touch Comfort

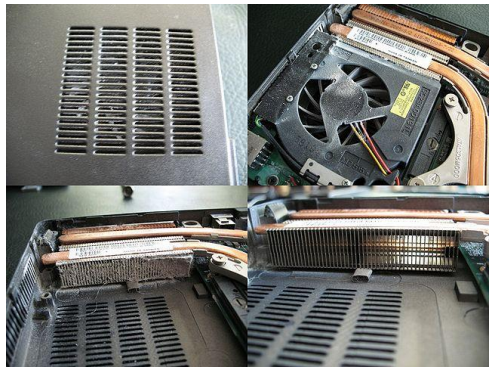
- Transition to wearable devices makes touch comfort a primary design metric
- Longer duration contact → lower temperature limits
- Perception of comfort varies significantly from person to person. Depends on perfusion rate and thickness of various skin layers.





Appearance

- Smaller is preferred
- No-one likes exposed vents



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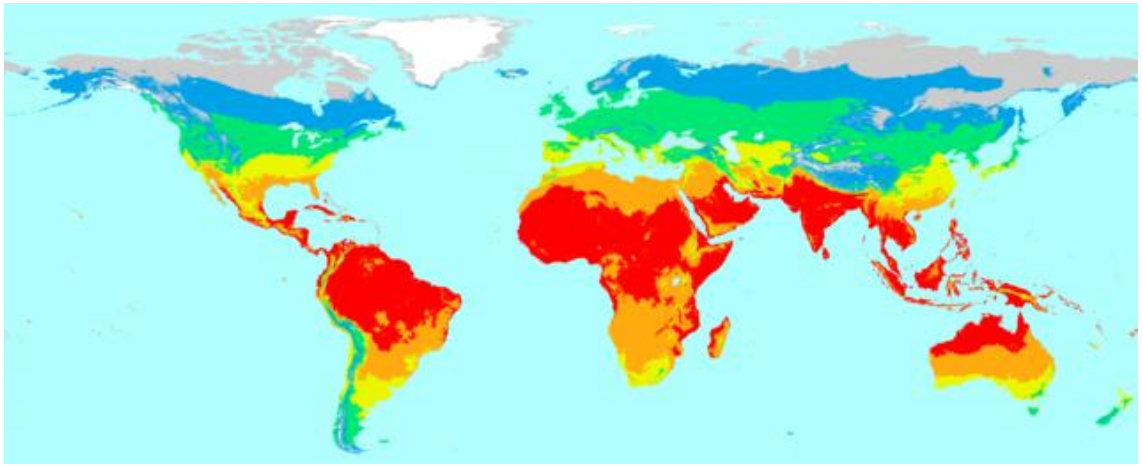
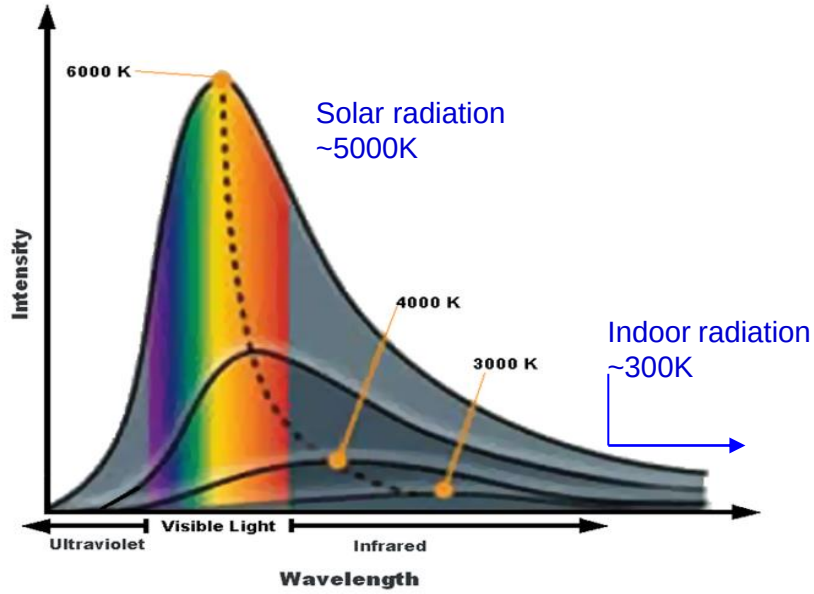
Usage & Environmental Conditions

Who are we designing for ?



Indoor or Outdoor or Both ?



How much wind speed should be accounted for ?

- Design conditions better than in-field ➔ Performance ←→ Reliability
- Design conditions worse than in-field ➔ Compromised user experience.

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Takeaways

- More performance → More power → More heat (generally)
- Miniaturization has made heat dissipation more challenging
- Qualitative constraints of user experience are becoming increasingly important.
- Keeping the customer and usage in mind is critical to strike a balance between performance, reliability and user-experience.

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