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Product Carbon Footprint

With global manufacturing and production sector accounts for **one-fifth of carbon emissions** – consuming **54% of the world’s energy sources** – accurately quantifying the greenhouse gas (GHG) emissions associated with products and activities is crucial for organizations to understand and mitigate their environmental impact.

Bill of Materials (BOM) - a comprehensive list of all parts, materials, and quantities required to manufacture a product - is essential to estimate the carbon impacts of materials and manufacturing processes.

We picked solid state drive (SSD) for our case study as it is a representative electronics product, and can contribute >75% to the manufacturing emissions

of a compute server. SSDs are complex and can have 30+ parts in the BOM, here we use wooden table as an illustration of a simplified BOM.

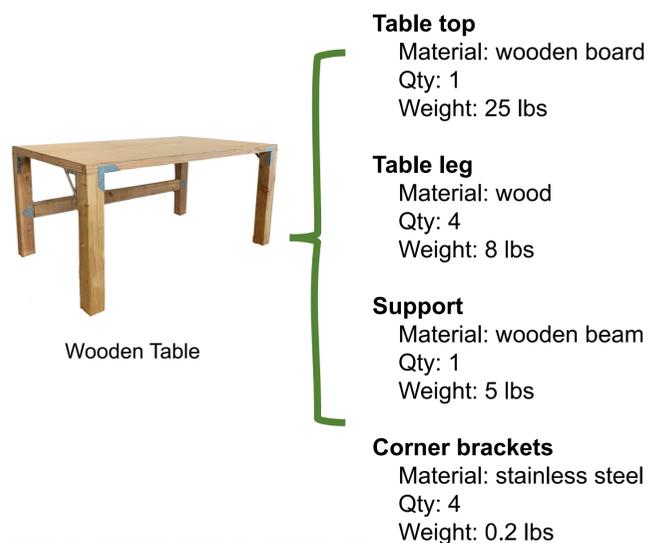
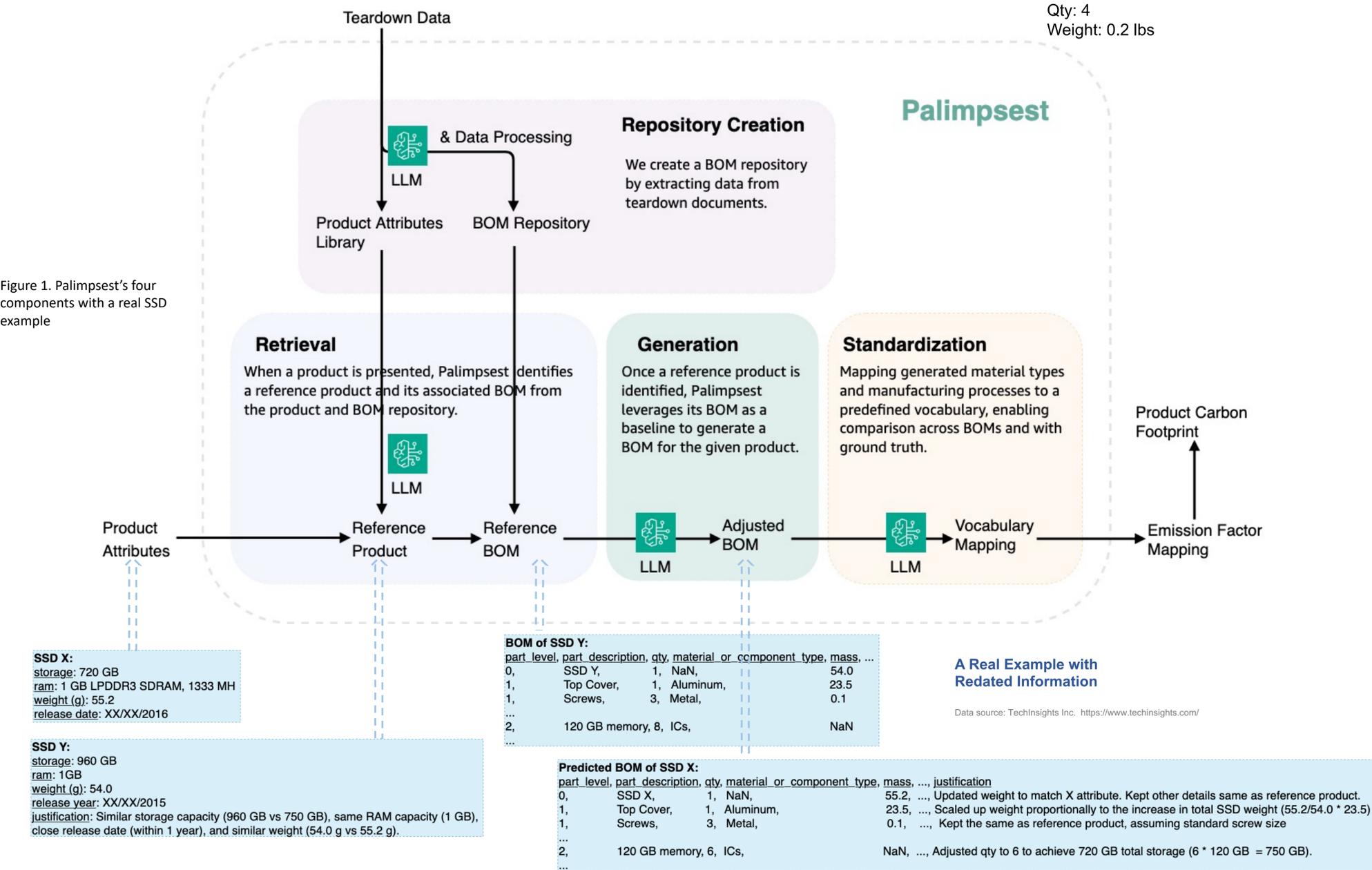


Figure 1. Palimpsest’s four components with a real SSD example



We use Claude 3.5 Sonnet as our LLM, and conduct in-context learning in each step.

Model	MAPE	RMSE	Weighted F1
Palimpsest	64.64%	211.80	0.9948
Naive LLM	72.43%	264.76	0.9601
EEIO	62.24%	239.28	NA

The performance of Palimpsest is benchmarked against a Naive LLM baseline, in which the model is tasked to generate a BOM using zero-shot approach.

Naive LLM lacks diversity in BOM prediction and consistently underestimates carbon emissions.

Of the 112 predicted BOMs, only one has emissions exceeding 150 kgCO₂e, compared to 42 BOMs in the ground truth, with some emissions as high as 927 kgCO₂e. In contrast, Palimpsest improves this distribution significantly, with 30 predicted BOMs exceeding 150 kgCO₂e.

* Palimpsest provides practitioners a jump start for emission hotspot analysis, and it should be treated as an estimation and does not replace the collection of primary BOM data.

Scalability

Traditional methods of compiling BOM data are time-intensive and resource-heavy, often requiring subject matter experts to invest weeks or even month to collect and validate the necessary information.

Palimpsest can predict BOMs within minutes, saving both time and costs associated with PCF. Practitioners can use this tool as a jump start for hotspot analysis, supporting organizations decarbonization strategy planning.

References

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[2] Callie W Babbitt, et al.
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