James Stowe
PIT Final Project
Periodic Table of Arduino

The Periodic Table of Arduino

Objectives

This note has two objectives:

1) To elucidate a minimal set of elements necessary to construct an Arduino Uno (hereafter Uno).
2) To map the complexity of the supply chain necessary to construct an Uno.

Prior Work

The author performed several searches for a study similar to this one. There is some interesting reporting done on iPhones, detailing the rare earths that are used for production. Another infographic for smartphones here. Neither of these sources claim to be complete or minimal. No work seems to have been done on Arduino.

Methodology

The original bill of material was sourced from the Arduino website and is stored here. This list provided the basis for all subsequent research. The author sourced datasheets from DigiKey for all of the components. Datasheets provided here.

The components themselves separated into two classes: those that had detailed information about materials in their datasheets and those that did not. For those that did, it was a straightforward exercise to look up the chemical composition for those components. For those that did not, the author searched out comparable items on Digikey and looked up specific construction techniques. Notable among the class that did not have detailed material information were the integrated circuits, diodes and LEDs. Luckily, these items are not complex in terms of materials; information sourced from here and here[1].

There are some further difficulties.

Companies are unlikely to release information about specific materials they use for construction. They will usually go with a general name, like thermoplastic, rather than an explicitly specced out formula, like nylon or acrylic. Faced with this difficulty, the author research common material types and chose the one with the *fewest elements* or that would *add the fewest elements* to the total set. The author felt justified in these choices because the purpose of the exercise is to discover a lower bound of the elemental complexity of the Uno.

Probably the shakiest bit of reporting in this note has to do with supply chains. Two primary difficulties confronted the author. On the first tier of the supply chain, all of the firms reported locations of plants, but did not detail specifically which plants produced which SKUs. The author relied on two metrics to select specific locations. First, if the general class of products the plants produced was detailed, the author chose the one that most closely aligned with the SKU under study (this method comprises a large majority of the items). If the company declined to provide information about the production portfolio of their plants, the author chose the plant that was closest to the Arduino production facility in Turin, Italy. On the second tier of the supply chain (i.e.

[1] Fascinating 'how to' for homemade transistors here.

materials), there is no visibility. Companies did not readily detail their suppliers and in many cases, especially with the metallic components, they are commodities. This means that they are readily purchased on exchanges and there is unlikely to be a single supplier. To deal with this, the author searched out which countries were the largest producers of those commodities and marked those countries as sources (China accounted for about ~80% of the materials).

It should be emphasized that the supply Chain map represents a visualization of the complexity of the supply chain, rather than an accurate representation.

Results

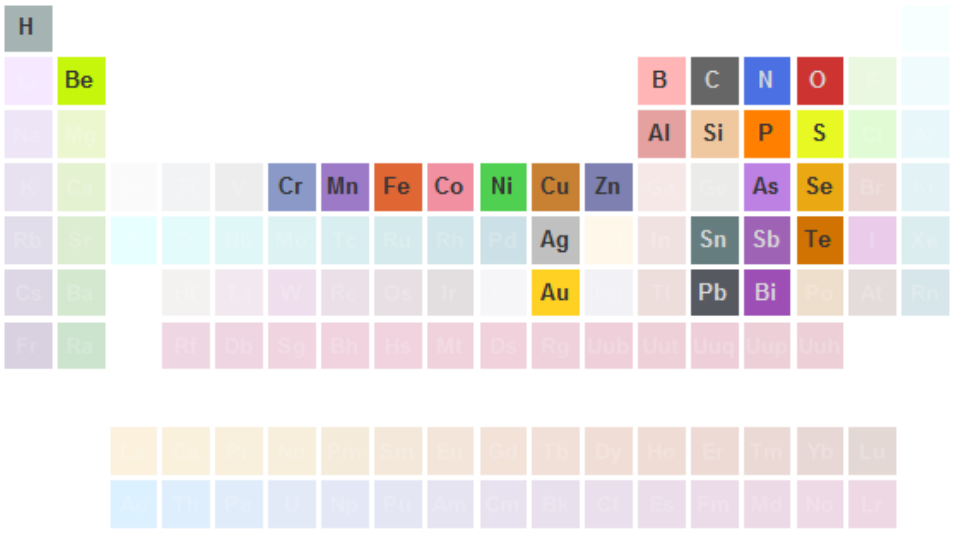

Figure.1: Minimal Periodic Table for an Arduino Uno. Twenty six elements are necessary.

Figure. 2: Overall supply chain visualization. Purple lines indicate 2nd tier flows. Orange, first tier flows

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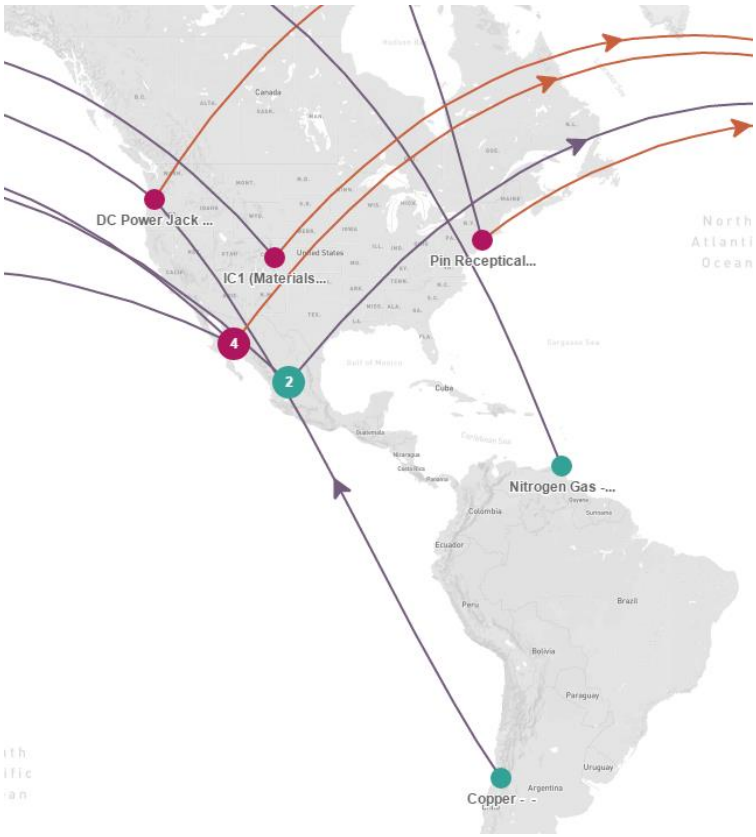

Figure 3: The Americas.

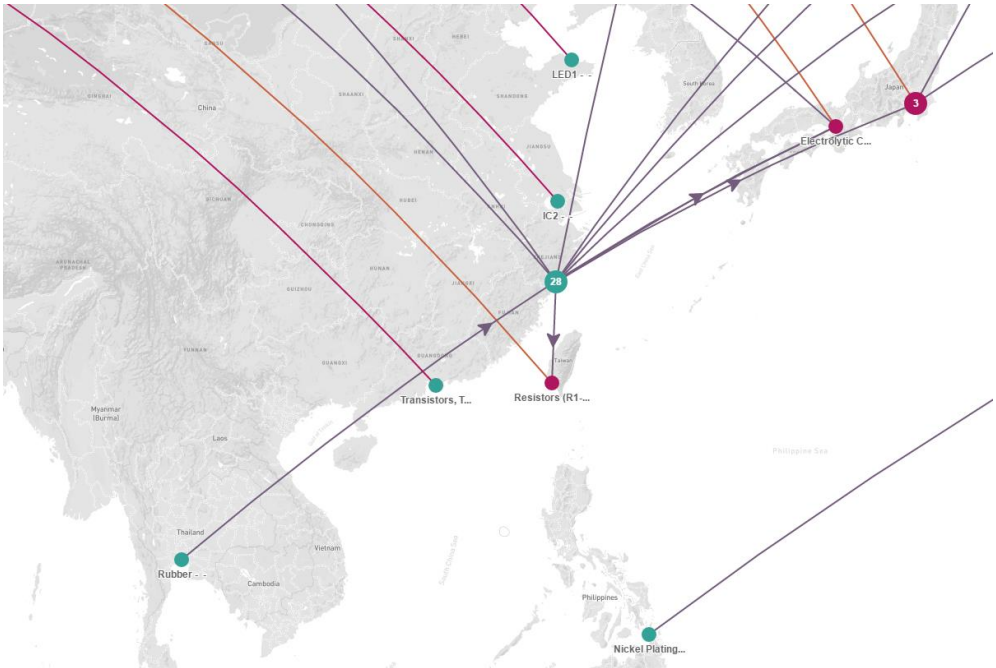

Figure 4: Asia

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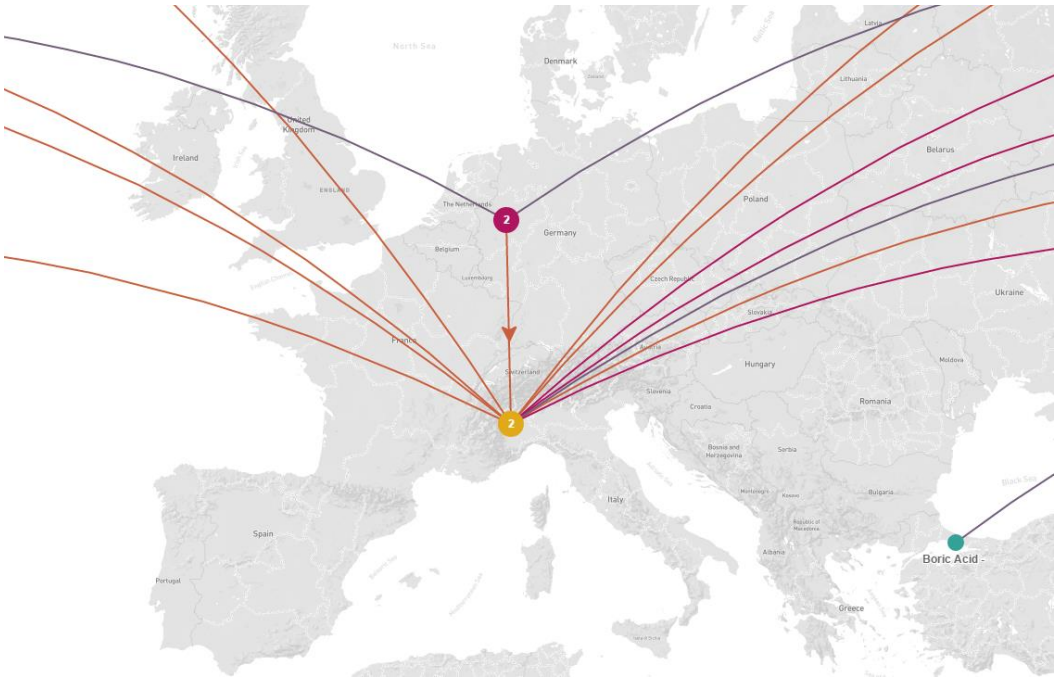

Figure.5: Europe.

A complete bill of materials and elements is provided here.

Verification

We can take some comfort from the fact that much of the elements listed in the smart phone investigations are included within our set. Other than that, there is little to compare. We may note that the set "seems right" in the sense that it includes many major elements that we've come to expect from plastics and the red metals that are well represented within electronics.

Implications

The bounding of the elemental and logistical complexity of assembling an Arduino gives us a good benchmark for the reduction in complexity that could be accomplished with digital fabrication techniques, such as Will Langford's.