June 2021

USING MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE TO MINIMIZE SHIPPING COSTS OF CONSUMABLES IN A SUBSCRIPTION OR MPS SYSTEM

HP INC

Using machine learning and artificial intelligence to minimize shipping costs of consumables in a subscription or MPS system

Abstract

A user of a consumable product needs to know when the consumable will reach end of life (EOL). This enables the user to purchase a replacement consumable to both avoid wasting any remaining material of the product by replacing it too early as well as being able to have a replacement on hand and avoid the inability to use the product.

Within the print business, the instant supplies and managed print programs are designed to provide customers a worry-free printing experience. These programs allow the customer to pay on either a fixed or a per-page basis. In this model the print provider is responsible for providing the printing supplies so that the customer never runs out of printing material. The print provider retains ownership of the supplies, but the customer controls the usage.

There are a few key cost drivers to the print supplies provider. One is the cost of the cartridge. The other is the logistics/shipping costs. It is obviously desirable to minimize these costs while providing worry-free printing to the customer.

Print devices may use different types of supplies components that may be comprised of an all-in-one print cartridge or multi-part print cartridges. The all-in-one print cartridge is comprised of the developer, drum, and print material (toner) all in one replaceable unit. The multi-part print cartridges have any combination of separate units for each. For example, a separate drum and a separate developer/toner unit. A color print device would multiply the number of components up to 4 times; each for the specific primary color (cyan, magenta, yellow, black).

It is recognized that shipping multiple items in one box is more cost effective than shipping individual items in their own boxes. This is because shipping costs are driven by both weight and volume of the box and multiple items can be packed more efficiently in one box, thus reducing the overall box volume of the shipment.

It is therefore desirable to ship multiple replacement consumables at the same time (and in the same box). However, printing supplies do not reach the end of their useful life at the same time. Replacing a print supply early, even if it resulted in an optimized shipment, may result in higher effective costs due to the unused value in the cartridge.

This paper provides a method using machine learning and artificial intelligence (ML, AI) to determine if and which type of supply (e.g. an starter supply yield, a low capacity supply yield, or a high capacity supply yield, referred to as respectively as a “STR” yield, an “A” yield, and a “X” yield) should be combined in a shipment in a color print device. The term “yield” is meant to describe the number of pages that the print supply will deliver. The method seeks to maximize the useful life (e.g. avoid early supply replacement) of the replaced print supply and minimize shipping costs. Doing so also has the benefit of minimizing disruption of replacing multiple print supplies over a span of time rather than replacing a group of print supplies all at the same time.

Description of the concept

The concept that will be shared is based on communication between the re-ordering service, that is the technology used to dispatch a replacement supply (in the case of a user replaceable model) or a service technician (in the case of a service provider who replaces the supply) and the device itself which provides the estimate of the life remaining of the supply. Also, although the concept, in practice, would be applicable to all installed supplies in a device (e.g. multiple types of supply components, multiple color of supplies) it will be described simplistically using only 2 supplies for the purpose of clarity to the reader.

Figures 1 – 4 show the relationship between the pages remaining of a supply (Y-axis) and time (X-axis). It is understood that the device may track various measures of supply life (e.g. pixels used, rotations used, etc) and that it can be directly correlated to the estimated of the remaining number of pages a supply has before it reached EOL. Additionally, in this example 2 different supplies (a magenta and a cyan print cartridge) are shown and that each supply has three different stated pages yield, indicated by R for the "X" supply, Q for the "A" supply, and P for the "STR" supply.

In Figure 1 the magenta print supply has reached the reorder point (that is the point in life when the estimated number of pages has reached a value when a replacement supply should be sent in order to allow the customer to continue printing until a replacement supply while not resulting in an early replacement of the supply by sending a replacement too early). At this time, a determination is made if and which type of replacement supplies should be sent not only for Magenta, but for Cyan as well.

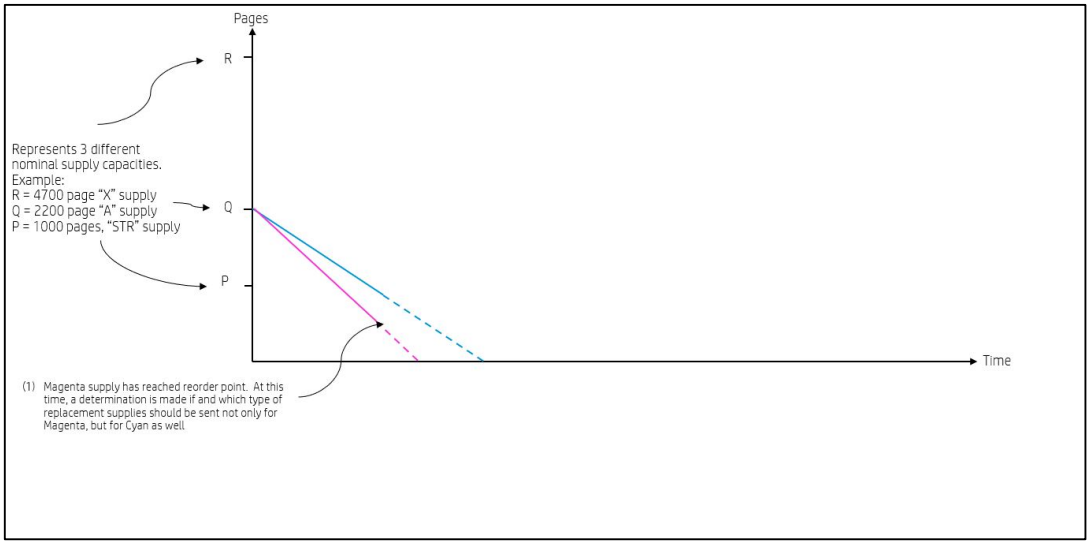

Figure 1- Magenta supply has reach order point

Figure 2 shows an extrapolation to when various supply capacity replacement cartridges would be installed based on historical print rates (pages / time). For example, at the expected timing of the magenta supply replacement three new projected alternatives is shown; each for the 3 combination of print capacities available M_P, M_Q, M_R. The projections of each show, based on the stated page yield and assuming historical print rate, the future date when each would reach EOL. This is similarly estimated for the cyan print supply. The estimated end date, shown as the symbol Ⓔ, are estimated for each color supply and each supply yield

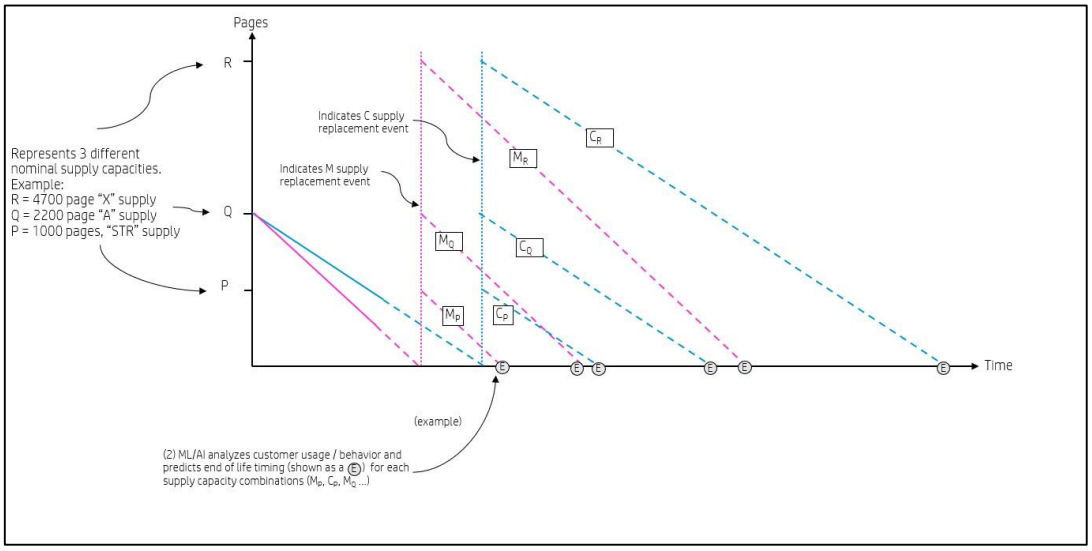

Figure 2- extrapolation to when various supply capacity replacement cartridges would be installed based on historical print rates (pages / time)

Figure 3 shows how the time delta between the time when each possible replacement magenta supply reaches EOL and when each possible replacement cyan supply reaches EOL. This is denoted as $t_{n,m}$ where n is replacement supply capacity (in our example P, Q, and R) and m is a unique value for each combination (1, 2, 3 in our example). In all, there are 9 combinations. It is evident that in this example, $t_{P,1}$ has the shortest time delta between the magenta supply M_Q and C_P.

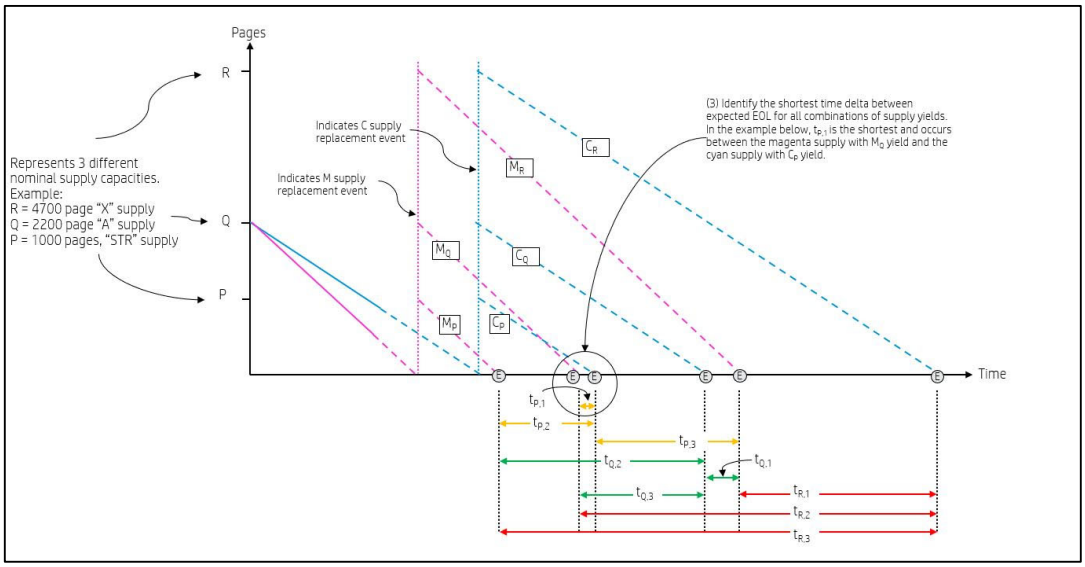

Figure 3- Comparison of different time delta's between possible replacement magenta and cyan print supplies

Figure 4 shows a less cluttered view with the M_Q and C_P replacement print supplies. The estimated time, $t_{P,1}$, between replacement of the M_Q and C_P supplies is used to calculate the amount of residual supplies life left in C_P if it is replaced at the same timing as supply M_Q. The residual supplies life is assigned a cost based on the providers cost (cost of cartridge and cost of service provider to replace cartridge, if applicable). Using ML/AI about the customers EOL behavior (ex: do they replace the supply once one arrives in the mail? Or do they wait until the printer prompts them to replace the supply?), a probability can be assigned to the risk of early replacement of supply C_P. An estimated

cost based on both the probability of early replacement and the residual cost of the supply are calculated and compared against the shipping/handling savings of combining the shipments of the M_Q and C_P supplies together. If the savings of combining the shipments together is greater than the probability-based estimate of early replacement, then both supplies M_Q and C_P are ordered when the installed Magenta cartridge reaches its reorder point. If the expected costs of early replacement exceed the expected savings, then only a replacement magenta supply is shipped. Other factors such as customer print volume, loyalty to the provider, etc can be used to determine the appropriate supply capacity to be used.

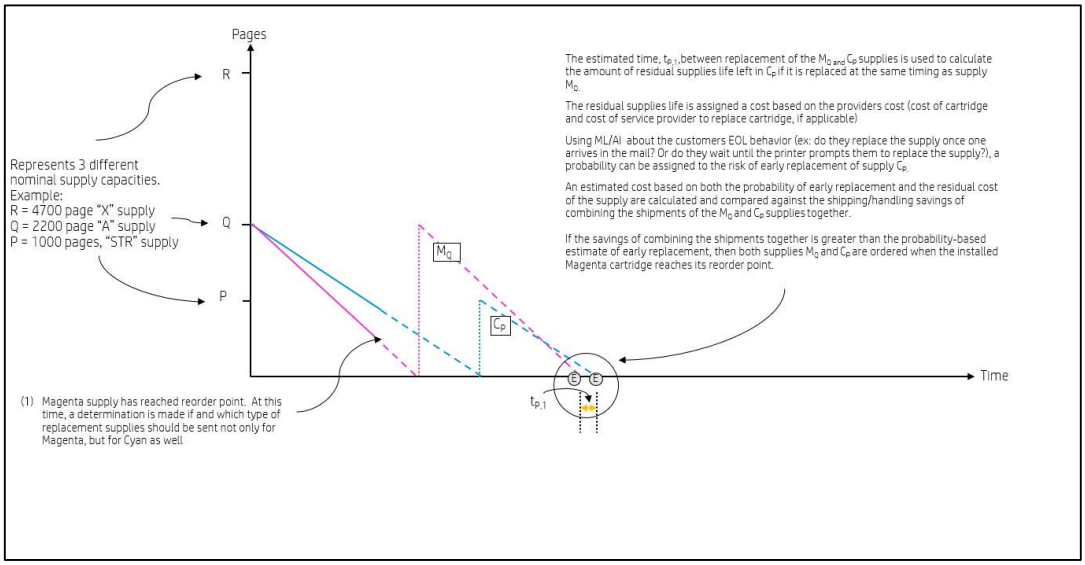

Figure 4- a less cluttered view with the MQ and CP replacement print supplies.

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