November 2019

ADAPTATIVE MAINTENANCE

HP INC

Adaptative Maintenance

1 Title

Adaptative maintenance

2 Abstract

In production printers, there are subsystems that require service maintenance to guarantee the full life of the product as well as the proper performance over time.

If the service maintenances are not followed, there is risk of part failures and unexpected printer downtime. The only way of reducing the unexpected printer interruptions is by enabling predictive service maintenance that allow the service organization to schedule the interventions on the printer before the problem occurs.

The new Adaptative maintenance system will allow company to adapt the service maintenance plan and the on-site interventions based on customer usage to only replace predictively the parts that are reaching end of life while keeping the maintenance cost at its optimal value. Service maintenance could be an important contributor in the Total Cost of Ownership (TCO), an important decision factor when customer consider a printer purchase.

This system is possible thanks to monitor the components usage, predicting when the components will face risk of failure and optimizing the operationalization of the service interventions.

The adaptative maintenance system will improve the up-time of the printer, the cost of service maintenance (TCO) and the service experience.

The adaptative maintenances will be one of the differentiators in next products value-added services.

3 Problems solved

Some electrical and mechanical subsystems degrade over time. In some cases, the degradation of components may occur during the life of the printer causing unexpected failures or performance loss.

The service maintenance intent is to prevent unexpected downtime to happen. If our systems can predict when a part needs to be replaced, the service representative can replace it before a problem appears.

Avoiding unexpected downtime is especially critical in high demanding productivity environments. Many Latex customers are running 24/7 shifts and any unexpected stop means severe damage to its production.

4 Prior solutions and limitations

There are usually two approaches towards service maintenances:

- Fixed Service maintenance plan at a certain usage level
    - Pros:
        - Single service maintenance visit
    - Cons:
        - All parts that could be degraded are replaced at the same time
        - The cost of the maintenance is high, as the number of parts is high.

- Some of the parts may have not reached the end of life.

- Individual part maintenance plan:
  - Pros:
    - Each part that could be degraded has its own maintenance plan.
    - Part replaced when needed
  - Cons:
    - Many service visits could happen in short periods of time, increasing the maintenance cost.
    - Perception of printer always under maintenance.

In the Adaptative maintenance, the advantages of each of the methods are used but avoiding the side effects.

5 New solution description

The new adaptative maintenance system takes advantage of having the equipment connected to the internet and our capacity of remote monitoring printer data.

During the development phase, the different failure modes of the printer subsystems are characterized. Based on the learnings and the reliability test results, the failure probability of the different parts gets calculated as shown in figure 1.

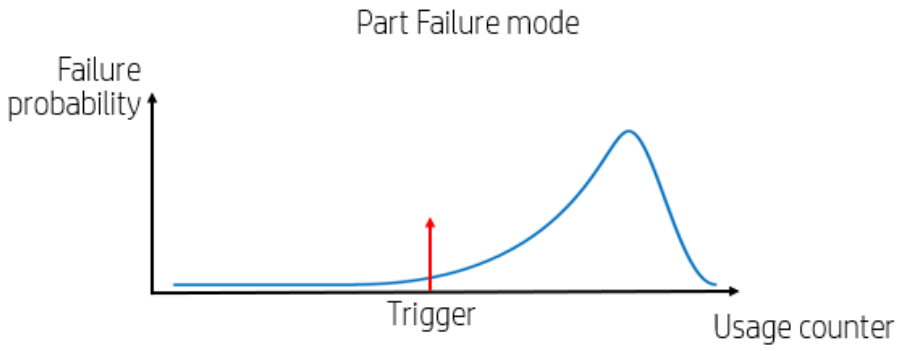

Figure 1Part failure mode

Parts which failures modes correlates with usage counters due to degradation are included under the maintenance plans. Some examples could be:

Usage counter	Subsystem s failure modes related
Time	Electronic components
Ink	Ink delivery system, curing module
Scan axis cycles	carriage and belt
Media consumption	Media path

A trigger is set to predictively replace the part before the failure probability and the downtime or performance loss appears in the printer.

In the adaptative maintenance system, each part which failure mode can be associated with an usage counter is monitored individually. The counter information is sent to the cloud, and we can monitor the status of all parts that may require maintenance.

In order to avoid frequent visits that will increase the maintenance cost, once the first service maintenance is triggered it looks for maintenances which due date is close to happen. A work order is created as well and sent to the service representative including all parts that will be required in a specific period of time.

Let's use figure 2 to as a theoretical example to further understand the concept:

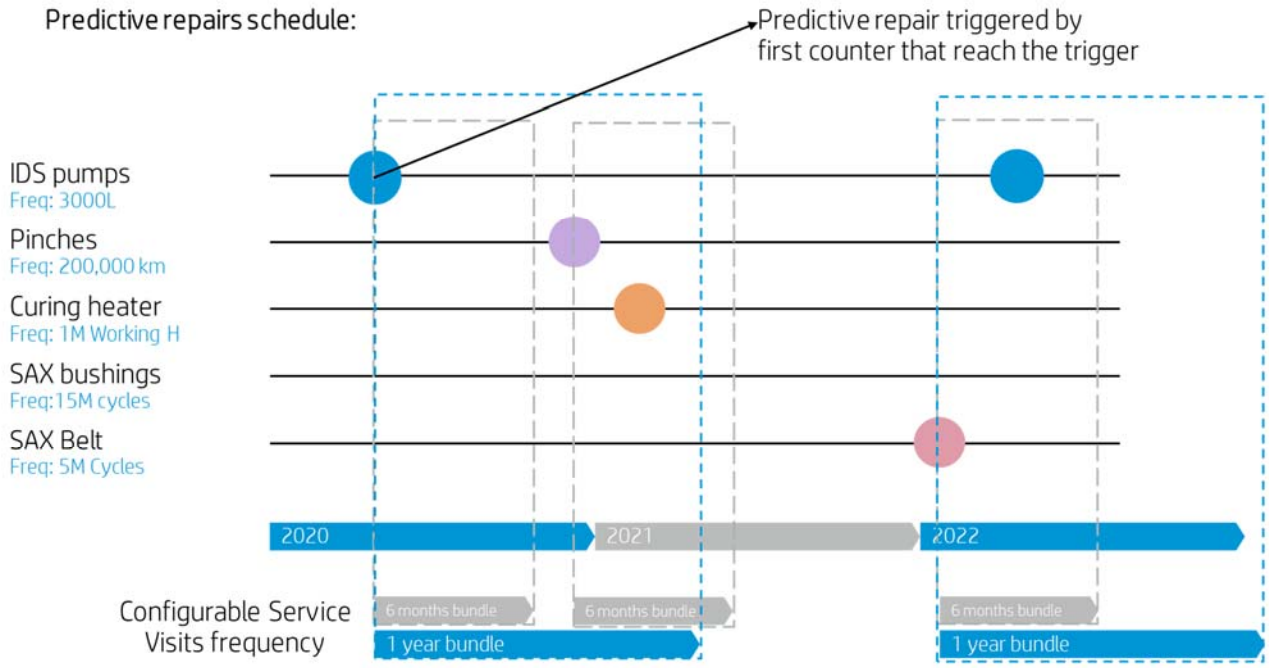

Figure 2 Adaptative maintenance example

In the example, the parts that will require maintenance are: Ink Delivery System (IDS) pumps, Pinches, Curing Heater, Scan Axis (SAX) bushings and SAX belt. The adaptative maintenances system is monitoring the printer raw data and estimating the due date of each of the parts.

The printer sends the raw data to the cloud. In the cloud is where the estimation algorithm is calculating the different estimation dates for each of the parts.

Once all due dates are calculated, we can represent a specific maintenance plan each customer, based on their actual usage of the printer.

As the printer is being used, when maintenance is getting closer (95% of completion) it triggers a process that evaluates the upcoming maintenances.

In the example shown in figure 3, the first part that requires maintenance is the IDS pump. If the system has been configured to do 1 service visit a year, once the trigger is reached the work order will include IDS pump, Pinches and Curing Heater.

The work order arrives to the service representative of the unit, and then it triggers the HW intervention.

The service representative contacts the customer proactively and inform him about the intervention that needs to be done.

At the end of the service intervention, the service engineer needs to confirm that the parts included in the work order have been replaced and the counters get reset.

The detailed Adaptative system flow and process is described is in figure 3:

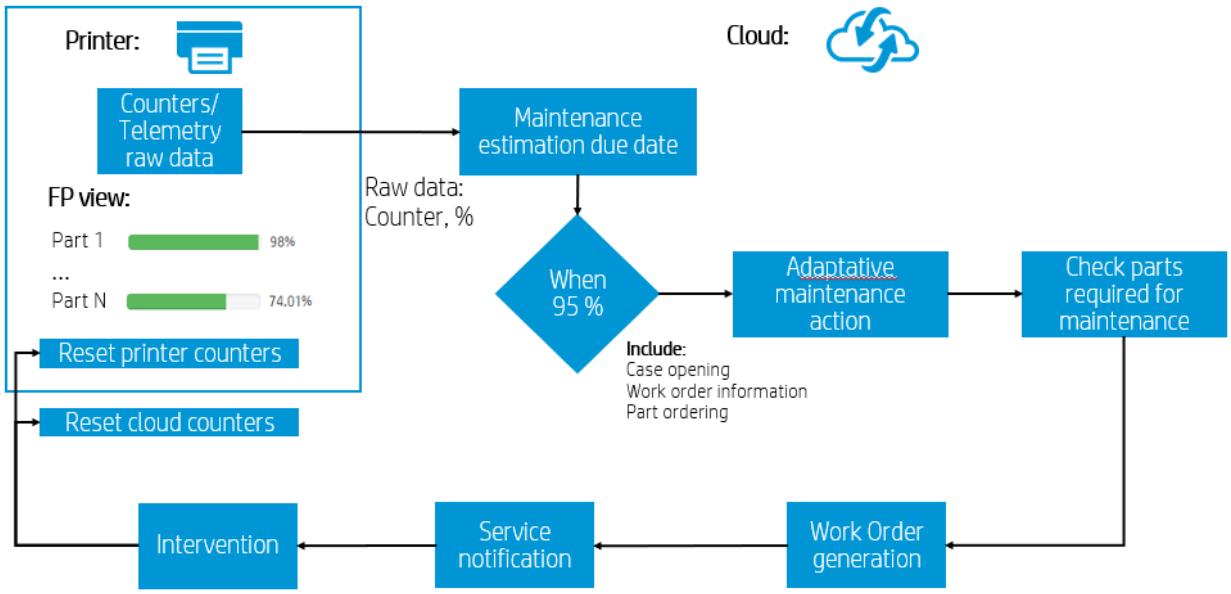

Figure 3Adaptative Maintenance system flow

6 Advantages of our invention

Customer trust in maintenances: Thanks to replace parts only when needed. With the adaptative maintenances we achieve to extend as much as possible the life of the different components of the printer, since the only parts replaced are the ones at end of life.

Lower TCO: Service maintenance visits and parts are optimized. Thus, the total cost of ownership gets reduced thanks to the reduction of maintenance costs.

Value added service: Company is owning the full control of printer service maintenance. A proactive approach can be used for replacing the parts and scheduling the service visits. The adaptative maintenances will be one of the differentiators in next products value-added services.

Customer satisfaction: In production environments, the above advantages will increase significantly our customer satisfaction. This service strategy will be a key winning differentiator against the competition.

7 Detectability

An adaptative maintenance system is in use if the service maintenance plan is modified and optimized using device information

Disclosed by Santiago Sanz, Ramon Barba and Roque Bonilla, HP Inc.