

the professional
labeling software

www.nicelabel.com
info@nicelabel.com



Understanding the Essentials of Label Printing Performance

The factors limiting your output capacity and how
to manage them

White Paper

Version 20080805-01

© 2008 Euro Plus d.o.o. & Niceware® International, LLC
All rights reserved.

Table of Contents

1	EXECUTIVE SUMMARY	3
2	A BREAKDOWN OF THE LABEL PRINTING PROCESS.....	4
2.1	PERFORMANCE PRINTING, WHERE AND WHEN.....	4
2.2	EXTERNAL FACTORS AFFECTING PERFORMANCE.....	5
3	PRINTING PROCESS STAGES AND THEIR IMPACT.....	6
3.1	LABEL DESIGN.....	6
3.2	PRINT ENGINE (MULTITHREADING).....	9
3.3	PRINTERS AND CONSUMABLES	12
4	CONCLUSION.....	13
5	APPENDIX	14

1 Executive Summary

Automation, modernization, performance... The production lines of the 21st century have turned efficiency into an art form, and yet, the labeling process often lags behind, needlessly slowing down the production pace. Labeling operations try to improve their efficiency by modernizing the hardware infrastructure, and all too often, they fail to achieve the desired results due to a fundamental error in approach. Label printing is an intricate system of data manipulation, and in order to maximize its efficiency, it needs to be approached from the ground up. An efficiently organized printing system strictly controls the data flow between the labeling applications and the printers, resulting in drastic increases in printing speed and flexibility.

In order to truly understand label printing performance, serving up some basic information or common questions and answers is not adequate. Simply updating or upgrading a system is usually not enough to improve the performance of a high-throughput label printing operation, as it's commonly being held back by a data transfer bottleneck. The approach to printing efficiency begins with the optimization of data, its distribution, and culminates in the expansion of the data transfer channels.

The printing process is composed of a handful of linear stages, and each of these stages can represent a bottleneck in high workload conditions. Because of this, even the most fiercely supported and advanced enterprise-level printing operations can struggle with an "invisible cap" on their output capacity. Buying better and faster printers, investing into top-of-the-line infrastructure and IT systems, work process reorganization, and similar measures do little or nothing to improve the capacity, if the printing data and automation are mismanaged or poorly organized.

This white paper aims to dispel the mysticism of label printing performance and break it down into its key components. It will provide a comprehensive view of the printing process, its stages, and the bottlenecks which determine the output capacity of the complete operation. It will explain how each of the stages determines the total capacity of the printing system, and show how adjustments to an individual stage can drastically affect the performance of the complete operation.

An optimized labeling system will deliver unparalleled printing performance, and most importantly, a scaleable operation which can be upgraded or expanded with traditional hardware measures. Once the data transfer bottlenecks are removed, an additional thermal printer adds to the total capacity of the system, finally allowing it to be scaled to fulfill the needs of the production line.

2 A breakdown of the label printing process

2.1 Performance printing, where and when

To truly understand performance printing, the definition of performance must first be established. As a broad generalization, performance is understood as a combination of quality, quantity, and speed, where all of the variables are balanced to an optimal degree.

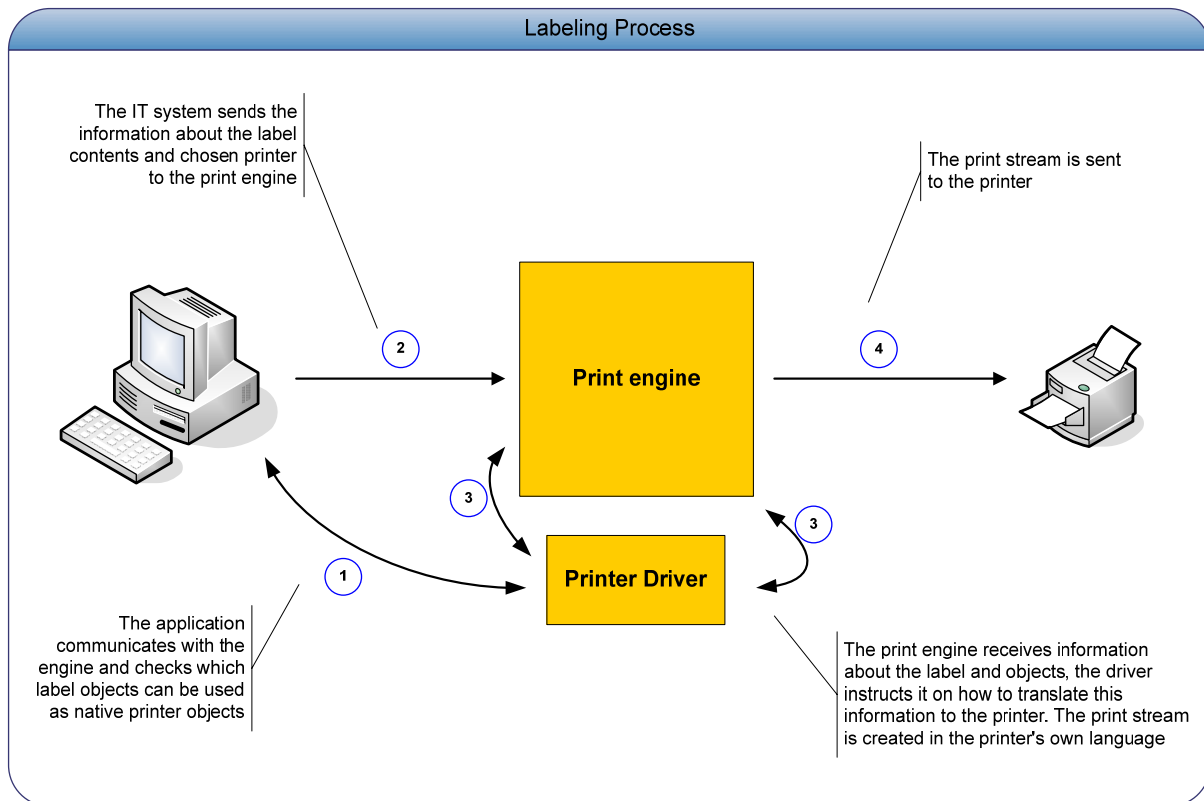
On the corporate labeling level, we'll take the liberty of assuming that quantity is a fixed value determined by the business process, and that labeling quality is determined by independent factors such as design, material, and printer quality. The quantity being demanded by business processes, and the quality being appropriate to the business criteria, the one factor that can be improved is speed.

Speed is defined as the ability to print large quantities of labels in a given time, as well as the response time of a label printing task. In an advanced production, packaging, shipping, or similar system, a delay of one process affects the whole line, and labeling is no exception. Although the ability to perform a labeling operation on-demand with no delay whatsoever is impossible, a performance labeling system should be able to very close to that mark, measuring delays in seconds or fractions of a second, instead of significantly delaying the production line.

To further define the speed factor, one has to understand that printing speed is a non-issue in environments where print jobs are small and scarce. Label printing speed becomes an issue when the system requires high label throughput or printing from a centralized IT system to a broad array of printers. As you will see in Chapter 3, distributed printing without optimization is at best an illusion, limiting production to one label at a time, regardless of the number of connected printers.

A properly optimized enterprise-level labeling system uses all of its resources all of the time, resulting in labels being printed immediately, when you need them, where you need them. After all, this is the core demand of the modern production line, and if every production stage follows this mantra, so should the labeling process.

The printing process is initiated the moment the print command is given to the printing application, and it ends when the printed product leaves the printer.



As the image indicates, the initial suspicion that the application connects directly to the printer is incorrect. The labeling software relies on the print engine to translate label data into print streams for the intended printers, as well as distribute the printing jobs between the connected printers.

While the print engine is an inevitable component of the process, it does represent a unique performance bottleneck. It can only process one print job at a time, which means that when several labels are being printed on various printers, they enter a queue and pass through the print engine in a sequence. To the last label in that queue, this means waiting for its predecessors to be processed, even though the printer that it should be printed on is idle.

The fact that labels are processed individually also reveals another crucial layer that must be considered in enterprise-level label printing. Printing any number of optimized labels to one printer usually doesn't cause a congestion of the print engine, as the engine's processing of labels is faster than the physical action of their printing (exceptions of extremely elaborate database objects and outdated hardware notwithstanding). However, enterprise-level users commonly use more than one label printer, and this is where the single engine meets his match. The distribution of labels to several printers represents an enormous potential increase to the output capacity, but the average printing system is capped at the speed of one printer.

2.2 External factors affecting performance

Printing performance is affected by several factors, much like any other data transfer and processing activity. The external circumstances that are likely to impact high-throughput labeling systems are:

- host system hardware (processor speed determines processing times, and RAM capacity can put a cap on the concurrent processes)
- operating systems impact performance to some extent
- printer driver (if printer drivers are compatible and connected to the labeling software that is initiating the printing, performance can be increased dramatically)
- printer connection (the physical connection of the printer to the workstation, outdated connection standards can be a severe bottleneck in the system)
- the material on which the label is printed, thermal printers operate by heating up the ribbon to transfer the image, and some materials require the paint to be applied at a higher temperature

3 Printing Process Stages and Their Impact

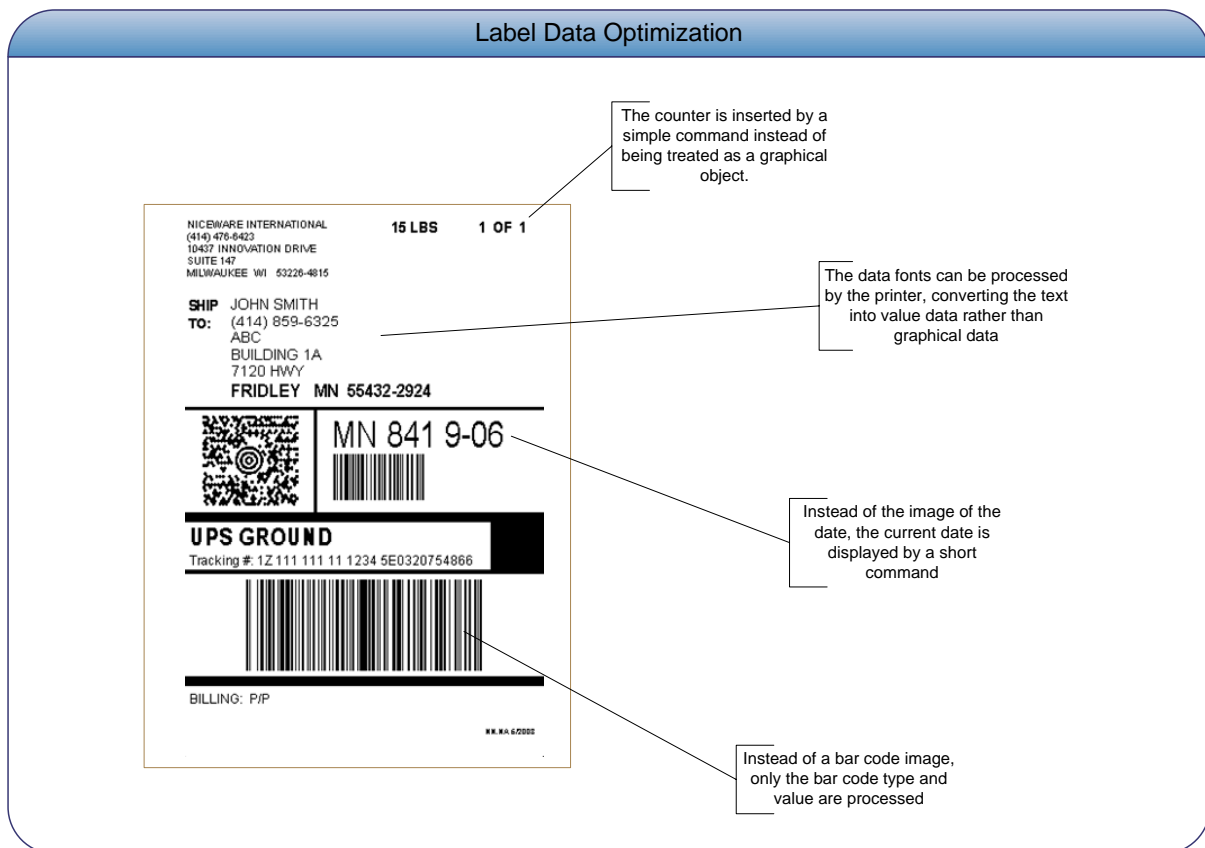
3.1 Label Design

Indeed, the first stage of optimization is an obvious one. At first glance, reducing the label’s “data footprint” is clearly the way to achieve better performance; as such a label would have an easier time getting to the end of the data line, and into paper form. While this is absolutely true, what does the “data footprint” concept actually mean?

As it has already been established that it’s the transfer of data that becomes problematic in high-intensity or distributed labeling environments, **the data footprint is the size of the information package describing the label.** In other words, this is the data that describes the label, which is sent out when the user clicks on the Print button.

There are many ways to optimize the label’s data footprint without significantly altering its contents. Obviously, reducing the number of graphics and content on the label is one of the choices, but a fairly unpopular one, as a seemingly trivial printing operation should not decide the final content of the label. This is where printer drivers become a crucial player in the system.

Most modern labeling printers are intelligent machines, with internal programming, storage, and processing. This allows the user to call upon certain functions instead of sending every last bit of information down the data transfer infrastructure. Instead of sending a detailed description of a label element, such as the complete image of a barcode, the printer can receive a barcode type command, and the value of it. The printer then processes this information and creates the barcode at the very end of the labeling process, saving valuable data transfer resources. It may even go as far as to tell the printer to print a label thousands of times, starting with a given serial number, and incrementing the serial number of all subsequent label prints by one.



The label data size significantly affects the complete flow of high-throughput printing processes by default. As the process reaches its capacity at any point, it does so due to its inability to handle the transfer and processing onslaught of thousands of labels. Smaller data packages to describe a label increase the capacity of the system, and allow for more labels to pass through in a given time.

The Store and Recall function is a particularly interesting option, which stores the complete label data including a few variable fields into the printer's internal memory. The computer printing labels can use this stored label and simply send over a tiny package of the data that fits into the variable fields, effectively reducing the quantity of information that is transferred during the printing process to a bare minimum. This is without a doubt the fastest way to print labels, where the response time between the moment print data is sent and the beginning of printing is almost null.

A simple **EAN13 barcode, size 3,29x2,26 cm**, is described by **1300 bytes** of data. The same barcode in the shape of a command, which would be converted into an identical image by the printer, takes up to **145 bytes**.

A simple conversion in how the barcode data is handled reduces its size by **90%**. This means that a simple software solution, combined with the data transfer reorganization as described in Chapter 3.2, can increase the capacity of the system tenfold.

3.1.1 Optimization of Custom Fonts and Graphics

Many specialized thermal printers feature several data optimization functions. One of them stands out somewhat, and should be explored in more detail.

Most of these printers include "internal" printer fonts, which are fonts programmed into the printer itself, making it possible to simply send a command to the printer, defining the text that should be printed in a certain font. The printer processes this command instead of requiring a full graphical description of the letters that appear on the label.

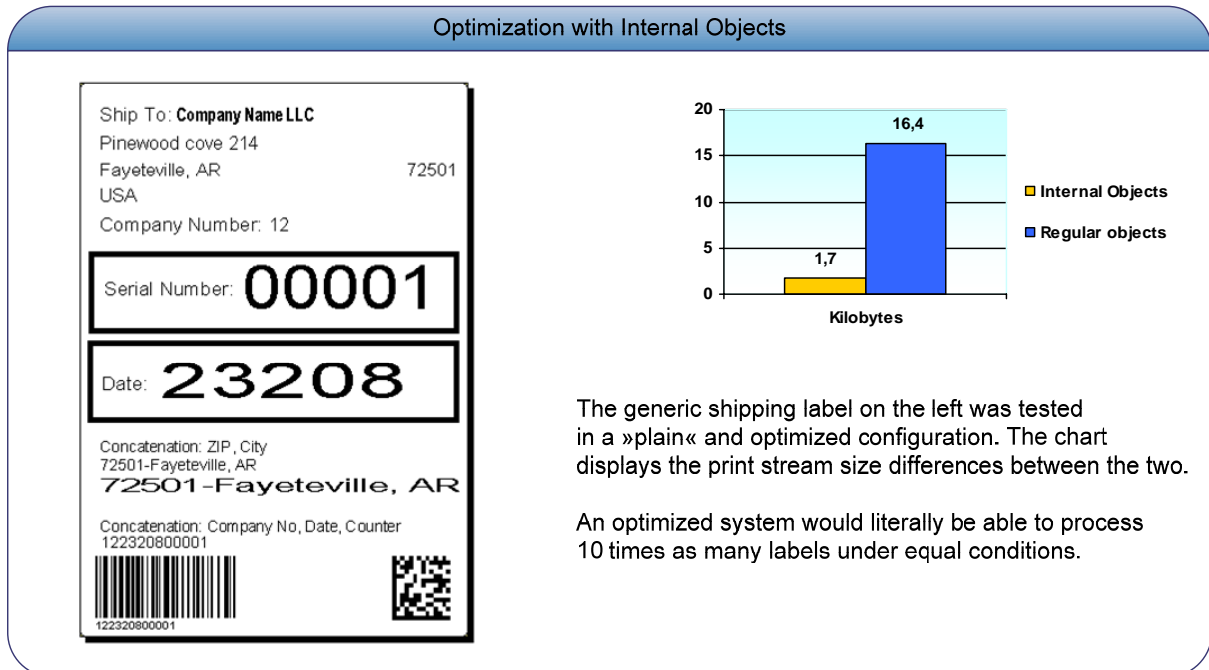
These fonts, however, do not always satisfy the design requirements of the labeling process. If a certain label requires an unsupported font, the internal fonts are of no use. This issue is solved by downloading these fonts (or common graphics) to the printer. The fonts and graphics are stored in the printer's internal memory, making it possible to expand the list of internal content.

Such fonts are used as if they were internally programmed, and the common graphics that appear on labels (such as a company logo) can be referenced by a simple filename. Both of these functions drastically reduce the data footprint of the label file, and greatly improve the system's label printing capacity.

3.1.2 Printer Drivers

An object's optimization capacity depends not only on the labeling application, but also the printer and the printer driver. The printer needs to support printer-internal elements, where instead of graphically printing objects, these are referred to with commands. If the printer is set up for such command processing, it usually includes a printer driver which refers to the same capability.

Without optimized printer drivers, the printer can't make use of its capabilities, because the printing application does not receive any information about internal objects, and simply forwards the label stream to the printer as graphical elements.



The individual optimizations that a printer driver might provide:

- **Internal font support**
 As simple as text seems to us in general, letters and numbers are no more to a computer than sequences of images. Instead of sending the complete images to the printer, a printer with internal font support enables you to send the "text" to the printer which is transformed into a graphical representation of the letters in the printer.
- **Internal bar code support**
 Instead of complete graphics representation of the bar code, only bar code type and contents are sent to the printer that includes internal bar codes as a printer command. The printer will image the bar code and print it on the label.
- **Storing part of the label in the printer's internal memory**
 The printer can remember the fixed part of the label, so the labeling software only sends the complete label data with the first label. For each subsequent label, only the changes from the previous label are sent.
- **Internal counters**
 Almost all thermal printers automatically support incrementing of serial numbers in text or bar code objects. This way, a series of labels with counters can be printed simply by sending the first label and the label quantity to the printer. The printer increases the counter on its own, there is no need to send counter values for each label.
- **Font and graphics downloading**
 Frequently used Windows fonts and graphics files can be stored in the printer's memory

(memory card, flash memory, internal memory, etc). Once the fonts or graphics files are stored in the printer, you can use them as printer internal built-in objects. You can reuse them on labels by simply sending appropriate commands to the printer (the printer driver manages transformations), minimizing the amount of data sent to the printer.

- **Storing label formats in a printer's memory for standalone printing**

Standalone printing (without the connection to a PC) is often required in the industry. Some printers support label template storage in the printer memory. The selection of the label format and data, as well as the label printing, is automatically done on the printer or with command files.

- **Programming RFID tags**

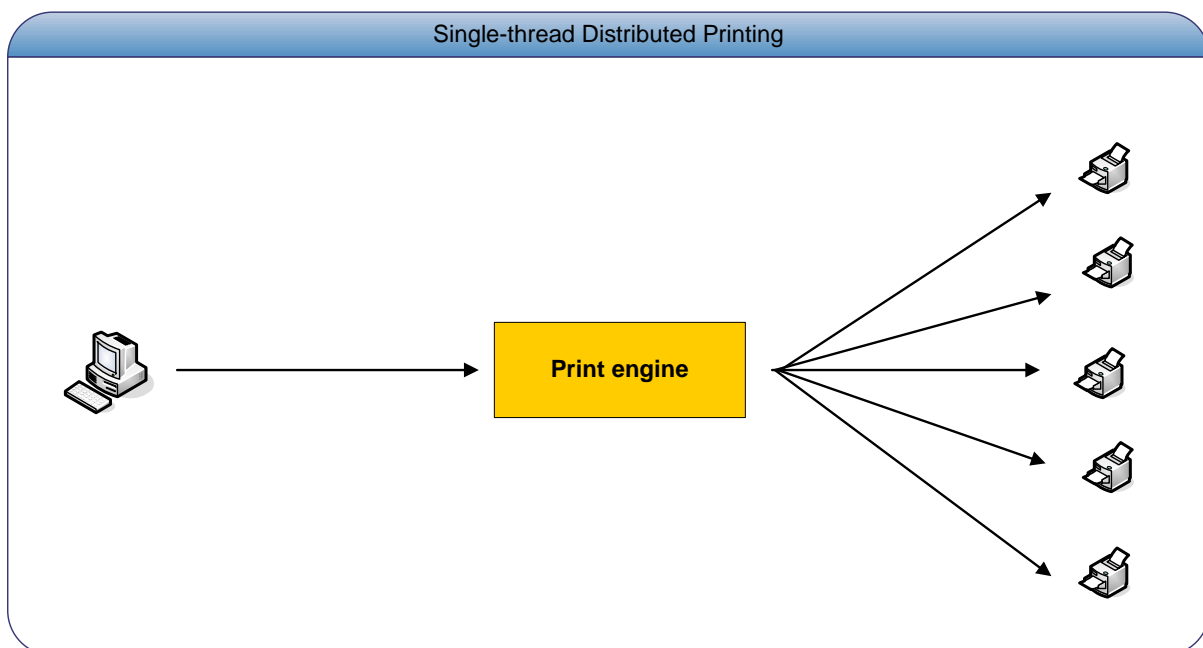
When smart labels are embedded with different RFID tags, it is very easy to print data on the label and store it in the RFID tag at the same time. Drivers may also extract the data already stored inside the tag, and use it in your information system.

Because there is no standard way of supporting these features on different label printers, optimal result can only be achieved by a combination of optimized identification software and matching printer drivers. Because of these limitations of printer drivers and models, there is no way to achieve optimal printing from common Windows applications.

Label printing performance depends heavily on the use of appropriate drivers, as the drivers increase printing speed through their optimization capabilities, and provide the option of printing fine-tuning, including the selection of printer types, materials on which the printing is done, printing quality and speed, etc.

3.2 Print Engine (Multithreading)

Once the label data is sent from the label design stage towards the printer, it lands in the print engine. The print engine receives the data describing the label, and its printer destination. As one workstation may print to a wide range of different printers, the engine receives a label description from the design application, and uses the printer driver to translate it into a language that the selected printer will understand.



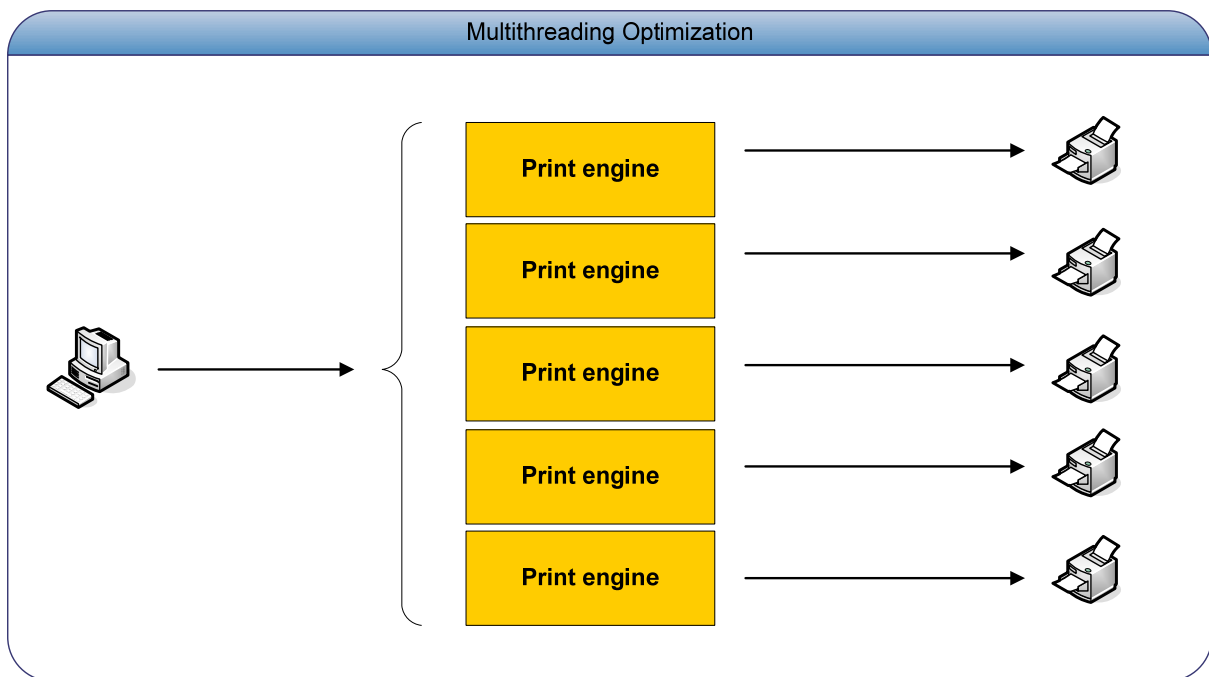
This is a fairly intense processing job for the print engine, and the engine handles labels sequentially. While the engine can process this information nearly instantly for smaller batches of simple labels, a high-performance operation tends to dump large amounts of complex labels onto the print engine.

3.2.1 Truly Distributed Printing

In a distributed printer environment, the engine will send a label for printing to the first printer, then to the second, and then the third, until it has sent one label to each of the waiting printers, then it will repeat the cycle. When one observes such an operation, it is obvious that only one printer is printing at any given time, and the additional connected printers are completely redundant. Performance optimization demands that printers behave as one and print simultaneously.

Assuming that the label data is already optimized, the print engine bottleneck in the process cannot be alleviated by reducing the data size. The next logical step to take is to expand the data transfer infrastructure, and this is where the concept of multithreading shines. Multithreading essentially means that an overload of a print engine is avoided by adding additional engines. Advanced labeling software can distribute the printing load among several print engines simultaneously, drastically expanding (literally multiplying) the processing capacity.

Multithreading capacity is relatively rare in common labeling software products, and it is found primarily in the enterprise-level product lines of the market-leading software houses.

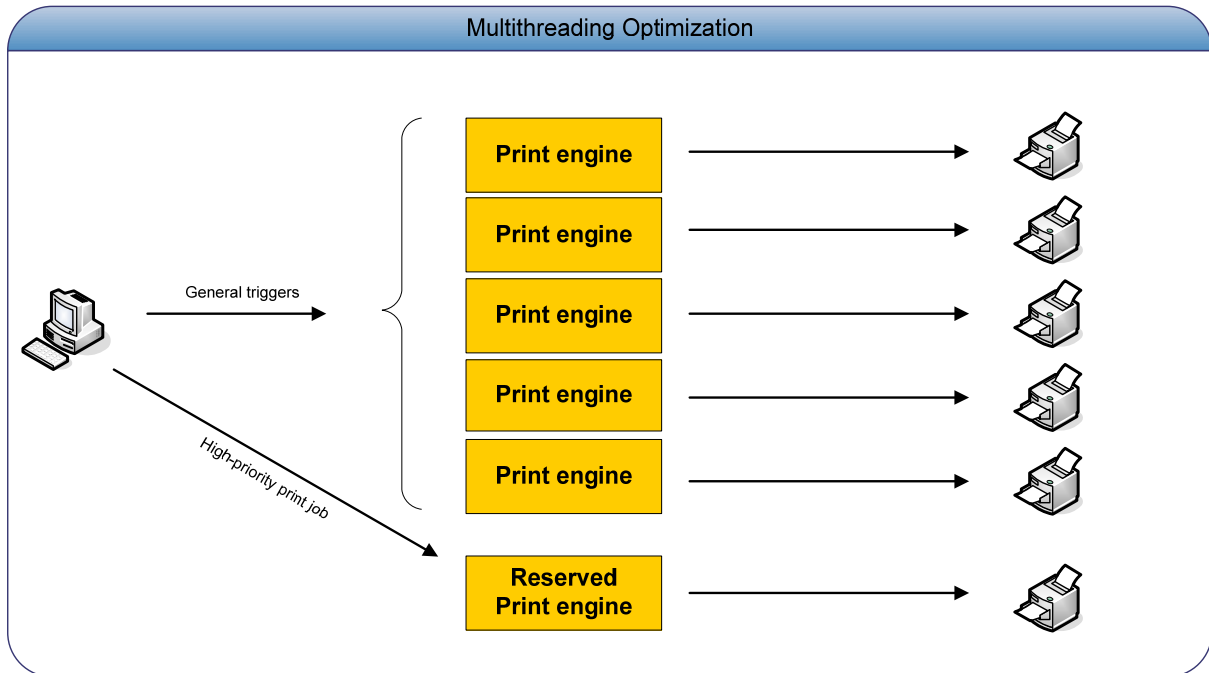


In a situation where the single-engine system was printing labels in a sequence between the printers, a multithreaded approach is the most potent and appropriate solution to the speed limitations of distributed printing. When additional print engines are used by the labeling application, each engine can assume control of its own printer (or a small share of the printer pool) and send label print commands to that printer.

The differences in distributed printing speed that multithreading offers are nothing short of dramatic. Although this optimization method is not applicable universally (it only applies in cases where several printers are in use), it is the most significant one.

3.2.2 High Priority Print Jobs

In addition to the above scenario multithreading allows for a print engine to be reserved for individual printing operations, allowing high-priority print jobs to bypass the engines handling the heavy loads of constant label printing, and use their own, reserved engine and head directly to their destination printer. During heavy printing activity, the engines are already working with long queues, therefore a new print job would enter the queue and wait for its turn. A dedicated engine for priority prints offers the capability to bypass this operation and instantly print an individual batch of labels.



In this way, multithreading provides the system with both a drastic improvement of printing speed, and near-instant printing of priority labels. The system is fully modular, and can be altered to prioritize any printing task, or several of them.

3.3 Printers and Consumables

Finally, we cannot overlook the hardware that does the printing. Modern label printers are advanced platforms that have seen lots of development since the early models. They contain their own programming and processing capabilities, and in some cases data management and feedback functions.

The connection interfaces of the printers have evolved with time, and some of the older models use connection standards that are not on par with the latest printing processes. Serial port and the older LPT ports (SPP) are awfully slow, while the newer LPT standards EPP/ECP and the latest LAN and USB connections are much faster.

A printer that is physically capable of printing a gigantic number of labels in a short time may not be the best choice for a performance labeling environment regardless of its physical capacity. Even though the printer might be able to physically dish out an impressive stream of labels, optimization of the label and dataflow is vital to the overall performance of the system.

If a printer does not support a certain font, a counter function, a date function, a barcode function, and similar, most of the optimizations done at stages one and two are inconsequential. The print engine and printer driver will detect the printer's inability to use such elements and will convert the objects to plain graphical objects. Furthermore, printing on special surfaces, such as plastic cards, metallic surfaces, uneven surfaces, etc can impact printing speed significantly. Thermal transfer printers generally need to apply a much higher temperature to the ribbon for the paint to imprint onto the surface, and the lack of absorption may require a slower printer setting in the driver as well.

The Store and Recall feature is also a defining characteristic of printers. As pointed out above, the Store and Recall feature saves all the fixed information of a label or label batch into the printer's internal memory. Only the variable information is then sent to the printer, where it is implanted into the stored label before printing. Needless to say, if the printer does not support this feature, the software support for it is irrelevant, and such functionality is not available to the operation.

4 Conclusion

Printing performance is an elusive concept, which can be interpreted in several ways. Keeping the business operation of label printing in mind, it becomes obvious that the content of labels and the printed quantity of labels cannot be leveraged as factors where printing performance improvements are possible. The business processes demand a certain number and the content of labels, so the way to increase or optimize the performance of an advanced labeling system is to maximize the speed of label production.

Another aspect of performance optimization can be found in the prioritizing of label printing. When a system is tasked with printing several batches of different labels, the choice of declaring a certain label printing task as a priority offers a new level of control to the output of the system as a whole.

The tests performed on a high-throughput scenario of label printing clearly show that label printing performance depends on the three bottlenecks in the data processing workflow. When label size is optimized, additional print engines are available to distributed printing, and when the printer itself supports the features of modern label printing systems, the data flow is uninhibited, providing unparalleled label printing speed.

If any of the 3 stages of label printing optimization is neglected, it creates a data flow bottleneck, limiting the printing system's capacity.

The printing technology that is available today makes optimized printing a very reachable goal which, unlike many other layers of IT business support, does not require a significant investment of resources or effort. Most systems currently performing label printing operations are already optimized to some extent, and merely require improvements to one or two stages of the operation to make full use of their capacity.

5 Appendix

Additional resources

Additional documentation is available, detailing the performance tests of the multithreading and dedicated engine scenarios in a distributed printing environment. As any detailed documentation of these processes also depends on the individual solution, the examples and workflows in additional specific documentation are based on NiceLabel products and the NiceLabel methodology of enterprise-level label printing performance and automation. The documents are available at <http://www.nicelabel.com/Learning-center>.

Performance White Papers:	<ul style="list-style-type: none"> ▪ White Paper: NiceWatch Enterprise Performance
General NiceLabel resources	<ul style="list-style-type: none"> ▪ NiceLabel Web site Learning Center ▪ NiceLabel Tutorials ▪ NiceLabel Technical FAQ ▪ NiceLabel Technical Support site ▪ NiceLabel forums

Technical Contacts

Head Office

Euro Plus d.o.o.

Ulica Lojzeta Hrovata 4c
SI-4000 Kranj, Slovenia
+386 4 280 50 00 Tel
+386 4 233 11 48 Fax

www.europlus.si
info@europlus.si

NiceLabel France

Cobarsoft SARL

6 rue Salengro
ZI hippodrome
32000 Auch
France
+33 (0) 562 709 201 Tel
+33 (0) 562 708 004 Fax

support@nicelabel.fr
www.nicelabel.fr

North American Office

Niceware International, LLC

10437 Innovation Drive, Suite 147
Milwaukee, WI 53226
+1 414 476 6423 Tel
+1 414 476 7955 Fax

www.nicewareintl.com
sales@nicewareintl.com
support@nicewareintl.com

German Office

NiceLabel Germany GmbH

Liebknechtstr. 29
63179 Obertshausen
Germany
+49 (0)6104 405 400 Tel
+49 (0)6104 405 4020 Fax

info@nicelabel.de
www.nicelabel.de