Comments on Draft 1
Electronics for Imaging, Inc. (EFI)
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As you may be aware, Electronics for Imaging, Inc. (EFI) is a large manufacture of internal and external Digital Front End (DFE) systems under the Fiery brand which are sold to OEM imaging equipment companies such as Canon, Konica Minolta, Oce, Oki, Ricoh, Sharp and Xerox to name a few. The Digital Front End equipment that EFI manufactures connect to a wide variety of printers, copiers, and scanners from departmental up through multi-thousand image-per-minute digital presses, and because of this equipment and application mix I believe that EFI can offer unique insight into the issues surrounding ENERGY STAR and DFEs. While I have some specific comments that I would like to make concerning Draft 1.1 of the ENERGY STAR Imaging Equipment specification, I would first like to present some background information that I hope we can use as a foundation/reference for all future DFE discussions.

Background

One of the primary functions performed by a DFE is to convert print jobs (e.g., PostScript, PCL, XPS, etc.) into a format compatible with the imaging equipment's marking engine. And to conserve network bandwidth or reduce the load on the sending computer, the software used to send the print job typically generates a description of the pages to be printed instead of a pre-rendered bitmap for each page. But since the imaging equipment's marking engine requires pixels; the DFE must convert each page description into a series of pixels that can be consumed by the marking engine. Some of the work required by the DFE to accomplish this task include: converting images contained in the page description into a color space that is compatible with the imaging equipment (e.g., RGB or YUV to CMYK), creating gradients and other shading that may be required by some graphic elements, converting text to the proper pixel representation based on the selected font, clipping/cropping the various page objects to create proper layering, applying a screen to the pixel data so that it can be used without modification by the marking engine, and possibly resizing the job to fit the selected output media size. Please note that most DFE manufacturers employ techniques such as compression to reduce the amount of pixels that have to move over internal busses and reduce "reverse order", "multiple copy", and "archive job" page data that is stored on disk to a manageable size. While the use of compression and other data reduction techniques may enable the DFE manufacturer to use lower-end systems with medium speed busses such as PCI instead of PCI-X or PCI Express, the DFE manufacturer typically has to create a video interface adapter that contains custom components to convert the compressed data into a pixel format that can be consumed by the marking engine. Finally, in order to support multiple copy printing, the DFE typically relies on either a large amount of internal DRAM or an internal hard disk drive to hold all the job's compressed pre-rendered pages for quick delivery to the video interface. Please note that even with compression, it may not be possible to hold an entire print job in internal memory, therefore the DFE manufacturer must ensure that the disk sub-system is capable of delivering data at a rate that supports multiple copy printing, which may require the use of a disk stripe set and a RAID controller.

Typically there are two interfaces between a DFE and marking engine, the first interface carries the video (i.e., the image pixels that are to be "marked" on the print media or scanner data), while the second interface is used for DFE and imaging equipment command/control/status communication. Now in some systems, a single video interface is used for both scan and print data; but a more typical configuration would have one interface cable to support print data and a second cable to carry scan data (this particular configuration is especially useful when the scanner connection to the DFE is optional). In most cases, the video interface between a DFE and the marking engine or scanner is proprietary and/or unique to the imaging equipment manufacture which usually necessitates the use of a custom interface adapter board in the DFE. Depending on the imaging equipment's capabilities, the video interface may only be required to carry a few megabytes per-second (MB/s) or in the case of a 72 impression-per-minute (IPM) printer using letter size paper at 600 DPI with eight bit contone CMYK pixels and four bits of tag data, the rate at which data has to move over the video interface is approximately 243 MB/s. Now using the same 72 IPM printer and increasing the DPI from 600 to 1200 or keeping the DPI at 600 but going from CMYK to Hexachrome requires the video interface to support a rate of 969 MB/s and 364 MB/s respectively. For reference, the pixel creation rate for a high-end computer game system generating scene data at 30 frames-per-second with a screen resolution of 1680 by 1050 RGB is approximately 159 MB/s, and unlike a game system that can drop the frame rate if the scene complexity becomes too high, a DFE must always deliver the data at rate or the marked media will be forever corrupted. Now the command/control/status interface, unlike the video interface, usually uses an industry standard electrical interface (e.g., RS-232 serial); but in most cases this control interface is required to run in the same cable as the video (i.e., a single connector for video and control communication) which therefore forces the control communication circuitry on to the same custom video interface card.

In addition to the marking engine interface, the DFE also contains one or more interfaces that enable it to communicate with external users and systems, usually through a standard network interface such as Ethernet. Due to requirements from EFI's OEM customers, all of the Fiery DFEs currently being shipped contain one or more 10/100/1000 BASE-T Ethernet connections and discussions are already taking place to determine when it will be cost effective to equip the Fiery with a 10 gigabit copper Ethernet connection. The use of industry standard networking protocols such as TCP/IP enables the DFE to work almost anywhere without modification and receive jobs from a variety of systems. But the disadvantage of using TCP/IP and some of the other networking protocols is that if the DFE does not respond to a socket open request within a very short period of time, the sending system will declare that the DFE can not be found, which causes problems for the DFE manufacturer and the end user's IT staff as both groups try to deal with all the "missing equipment" complaints. Because of the time requirements associated with socket open requests, the lowest possible sleep level that a DFE can usually support is ACPI System Level S3 (i.e., suspend to RAM, main DC power supply off).

As stated previously, the lowest sleep level that most DFE's can support in order to respond to new network open requests is S3. In addition to the S3 requirement, there are several other DFE energy profile aspects that should be mentioned. Specifically, some imaging equipment will not allow the DFE to enter sleep until the imaging equipment itself enters sleep (which according to the ENERGY STAR Imaging Specification could be up to 60 minutes for 51+ IPM MFDs). Please note that the main reason for delaying an MFD's sleep is to reduce the amount of time required for the Toner Fuzer Unit to warm-up and stabilize; but the DFE itself does not have a stabilization issue and should be allowed to enter sleep within a few minutes after completing a print job. Another issue that we have observed is that some imaging equipment will wake the DFE even when the operation being performed on the imaging equipment does not involve the DFE (e.g., copying).

One final point concerning DFE performance, most DFE manufacturers attempt to create systems that match as closely as possible the imaging equipment's media delivery rate. There are several obvious reasons for doing this (i.e., if an end user purchases a 72 IPM MFD, they expect it to print a "standard" job at 72 IPM, and in the case of a web based printing device, failure to deliver data at rate will result in wasted media) but there is also an energy saving aspect that comes into play when the DFE is matched to the imaging equipment's performance. Specifically, once the imaging equipment is placed into an active processing mode (highest possible power consumption), if the DFE fails to have data ready when the imaging equipment requests it, the imaging equipment will enter a "wait" state (i.e., a full power consuming state) until the data becomes available or a timeout (on the order of 15 seconds) occurs which causes the imaging equipment to transition to the "idle" state. For example, if a DFE caused the imaging equipment to wait one second before each page became ready to print and using our previous 72 IPM MFD example (which prints a page every 833 milliseconds) the amount of "active" time for each page increases by 120% which adds up to a substantial amount of energy wasted over the imaging equipment's life. In addition, the power consumed by some of the highest compute capable DFEs is considerably less than the active mode energy consumption of the imaging equipment it is driving, therefore it makes energy saving sense to limit the amount of "wait" time the imaging equipment experiences by matching DFE and imaging equipment performance, even if this means the DFE requires a five disk RAID, two quad core CPUs, and eight gigabytes of memory. Please note that market forces tend to keep a DFE's price at a percentage of the imaging equipment's price, therefore it is unlikely that someone would attach the aforementioned quad core DFE to a 30 IPM MFD; but would instead opt to use a lower price (i.e., lower power) single processor DFE that meets the 30 IPM performance requirement.

Testing a DFE under the ENERGY STAR Computer or Server Specifications

One conclusion that can be drawn from the previous background information is that while the tasks performed by all DFE's may be similar, the requirement to closely match imaging equipment performance can greatly increase the DFE's complexity and computational processing requirements as the imaging equipment's IPM rate increases. This can result in a DFE having dual quad core CPUs, a four hard disk drive hardware RAID 0 Stripe Set, dual 10/100/1000 BASE-T Ethernet controllers, four gigabytes of memory, and one or more custom imaging equipment interface boards (e.g., EFI's QX100 Fiery Server product line). Now the processing capability of the aforementioned DFE is more than most Enterprise Servers; but according to the "ENERGY STAR Program Requirements for Computer Servers: Draft 1" this system is not a server for the following reasons:

- The system does not contain a "Dedicated management controller, such as Baseboard Management Controller (BMC) or service processor", which you would not expect to be present on any Network Appliance given there special purpose design (i.e., allowing an IT administrator to change certain DFE settings could adversely affect the DFE and prevent it from operating correctly, typically the DFE provides a special web based or SMNP interface for IT management).
- The DFE does not posses "Certification for use with enterprise-class server Operating Systems". While our example DFE can run an enterprise-class operating system, the cost to include an Enterprise OS on the DFE is substantial and the DFE is capable of performing all its tasks using a non enterprise-class operating systems (e.g., Microsoft Windows XP Embedded or Linux), plus it is unclear whether a certifying group would consider issuing such a certificate to a non-enterprise DFE system.
- The DFE is not "Designed and placed on the market as a Class A product as per EN55022:1994 under the EMC Directive 89/336"; but is instead required to meet Class B EMC requirements.

In addition the same DFE can not be qualified as either a Workstation or Desktop Derived Server under "ENERGY STAR Program Requirements for Computers: Version 5.0 – Draft 1" for the following reasons:

- Workstation – The DFE is not "marketed as a workstation".

- Desktop Derived Server – The DFE has more than a single CPU socket, and the DFE does not use an “industry accepted operating system for standard server applications”.

Now according to “ENERGY STAR Program Requirements for Computers: Version 5.0 – Draft 1”, since the DFE in our example does not fit any of the specialized categories found in the document, it is therefore classified as a “Desktop Computer” (page 6 of the computer specification), and as such it is impossible for this DFE to meet ENERGY STAR given the low energy consumption requirements of this category. In fact it would be difficult for any DFE to fall into a category other than “Desktop Computer”, which means that only the lowest performing DFEs that do not contain an imaging equipment video interface adapter (i.e., the computer specification provides “capability adders” for memory and network interfaces but no adder for required add-in adapter cards) could possibly achieve ENERGY STAR certification.

In addition to the possible classification problems discussed previously, another potential issue with testing a DFE under the Computer Specification is the use of the EEPA tool (e.g., BAPCo’s EEcoMark) to simulate a workload. The first version of EEcoMark is scheduled for a June 2008 release and will run on Windows and MacOS, so how are external DFEs that run Linux or some other operating system (e.g., Microsoft’s Windows CE, or Green Hill Software’s INTEGRITY or velOSity RTOS) suppose to achieve ENERGY STAR certification, since EEcoMark can not be run under the DFE’s OS? Please note that it may not be possible to load Windows on to a DFE for EEcoMark testing, if the hardware or BIOS of that DFE was not designed to support the Windows OS. At present, the EEcoMark software is designed to simulate a Desktop Computer load and with modifications a Workstation load; but these EEcoMark workloads may not represent the workload a DFE will experience. For example, a DFE driving a 40 IPM MFD in a corporate setting may only print 10 to 15 jobs per day with an active period of several minutes per job; but the EEPA tool when run on the same DFE hardware may impose a workload with hundreds of active periods that when summed exceed both the ENERGY STAR criteria and the actual amount of “active time” the DFE would have accumulated when connected to its imaging equipment. In addition, under EEPA tool testing the DFE to imaging equipment interfaces are never exercised, so the power consumed by this interface (which could be substantial if older interface technology is used) may not be captured by the test procedure.

While trying to develop a single specification that will support ENERGY STAR testing on all computer based systems is a good idea and worth pursuing, given the issues described above and some that were not mentioned, it seems that trying to qualify DFEs under the ENERGY STAR Computer Specification will be difficult if not impossible and therefore should be dropped from the ENERGY STAR Imaging Equipment Specification. Please be aware that EFI has thought about how to test both internal and external DFEs under the ENERGY STAR

Imaging Equipment Specification and has provided some of this information in the following topic.

DFE Definition

One of the main reasons for creating a Digital Front End (DFE) definition in the "ENERGY STAR Program Requirements for Imaging Equipment (Version 1.0)" document was to differentiate between systems that contained a simple controller and those that required a higher performance computer system to print jobs and distribute scan data to various destinations. In the current Imaging Specification, the method for determining if the circuitry that connected the imaging equipment to a network was a DFE or a simple controller was whether it performed at least three of the specialized features listed in the specification. The problem with this DFE determination method was that over time the "simple controller" software evolved to add many of the features contained in the DFE definition list, which has therefore lead to most circuits that connect an Imaging Equipment to a network as being defined as a DFE.

In one sense the determination as to whether an Imaging Equipment contains either a "simple controller" or DFE is irrelevant, what really matters is the amount of energy consumed while performing a required task within established expectations (TEC approach) or the amount of energy consumed when the device is idle or sleeping (OM method). For example, a "simple controller" with a CPU clock running in the low kilohertz could take ten minutes to process a five page job and it avoids the "wait" time penalty described earlier by placing the imaging equipment into "idle" after each page is processed. Now from an energy consumption point-of-view this system would be hard to beat; but if the imaging equipment were a 40 IPM MFD then taking ten minutes to print five pages definitely fails the expectation test and would probably result in the controller being discarded, regardless of its potential energy savings. In another example, a "higher performance computer system" may be connected to an imaging equipment that has high "wait" and "idle" time power penalties, and because of this the computer system pre-renders all pages to disk which guarantees that the pages can be delivered without any "wait" time, and the imaging equipment is not brought out of "sleep/idle" until the job is completely pre-rendered to disk. In this scenario the computer system has to remain active for a longer time period (i.e., the time required to pre-render and store the pages to disk and the amount of time to read the pages from disk and send them to the imaging equipment) which causes the computer's TEC to be large and could result in failing to meet ENERGY STAR; but its possible that the TEC of the combined imaging equipment/computer system when operated in this mode could result in substantial energy savings which should merit ENERGY STAR certification. It is also possible to have a case where the "simple controller" meets expectations and achieves a very low TEC value when processing simple text only jobs; but when the job exceeds a certain size or requires all colors to be properly calibrated when rendered, then the "simple controller" may slow down substantially resulting in a high TEC value; whereas the "computer system" may have a higher TEC compared to the "simple controller" for simple text jobs but its TEC value remains constant regardless of job size or composition. In this case, should the "simple controller" or "computer system" receive ENERGY STAR certification? If the workload in the imaging equipment's target market mainly consists of simple text jobs with only a few large or managed color jobs, then the "simple controller" should receive ENERGY STAR; but if the job mix is random then the "computer system" may be the logical choice to receive ENERGY STAR. This last example brings up a complex issue concerning workload and target environment. For some imaging equipment it may be easy to determine the environment's job mix (e.g., a digital press will always require calibrated color). But if the imaging equipment can serve multiple environments (e.g., graphics arts and departmental printing) should the imaging equipment manufacturer be required to obtain two ENERGY STAR certifications one for the Graphics Art environment which uses the "computer system" and the other for Departmental Printing using the "simple controller"?

What the previous paragraph attempted to illustrate were some of the issues related to testing a DFE (which can be either a simple controller or high performance computer system) and its associated imaging equipment. In order to test a DFE using the Typical Electricity Consumption (TEC) Approach, numerous factors must be considered including task complexity and the DFE's affect on imaging equipment power consumption. This implies that for TEC testing a set of representative print and scan files (e.g., simple text, text with graphics, managed color images, etc.) will need to be adopted and used to guarantee consistent testing across DFEs and to generate realistic workloads. Please note that the file format for these test files will also need to be considered (e.g., PostScript, PCL, PDF, XPS, etc.), given that the format itself can affect DFE performance and its associated power consumption. In addition the TEC pass/fail criteria will need to take into account the amount of energy consumed to process each test job in relation to the job's IPM rate compared to the imaging equipment's IPM rate (i.e., expectation weighting), and a TEC weighting factor may need to be employed for each job type to correctly adjust for complexity (i.e., managed color compared to simple text). In contrast, testing a DFE using the Operational Mode (OM) Approach is extremely simple and just requires the measurement of Standby and Sleep power consumption (provided a DFE OM section is added to the specification). Now to completely support OM DFE testing, Interface 'A' (Wired < 20 MHz) of the "Qualifying Products: Table 3 – OM Functional Adders" (page 15) should be modified to include the DFE's ability to wake the imaging equipment and the imaging equipment's ability to wake the DFE. Of course the one disadvantage of using the OM over the TEC approach for DFE and/or imaging equipment testing is that active power is never measured and no expectation metric is possible (e.g., the "simple controller" that printed a five page job in ten minutes could have lower sleep and standby power consumption compared to a computer based DFE which meets user expectations, thus preventing the DFE from obtaining ENERGY STAR certification). When it comes to DFE ENERGY STAR testing, all of the possible test methods from both the Imaging and Computer Specifications present issues/problems that could make consistent DFE testing difficult.

As a final point, the following provides an alternative DFE definition that is in line with the information previously presented:

Digital Front End (DFE) – A functional block that connects to a network or other digital interface and is responsible for converting information received from the network/interface into a format that can be consumed by the imaging equipment, and/or for receiving and processing data from the imaging equipment for transmission over the network/interface. In addition, a DFE may expose one or more interfaces that enable the imaging equipment to be remotely managed, configured, and/or monitored, and the DFE may provide local archival storage for print jobs, scanned images, etc. A DFE is considered to be an "External DFE" if it has an AC power connection that is separate from the imaging equipment and is to be tested in accordance with the ENERGY STAR "TBD Specification/Procedure". If the DFE draws either AC or DC power from the imaging equipment, the DFE is considered internal. In the case of an Internal DFE, the imaging equipment manufacturer may either use the total power consumed by the DFE and imaging equipment to determine ENERGY STAR qualification under this specification or subtract the power consumed by the DFE from the imaging equipment and test the DFE as if it were an External DFE as described above.

In the above DFE definition the External DFE testing procedure was left "TBD" this is to reflect the concerns expressed above about how to fairly test a DFE for ENERGY STAR compliance.

Please forgive the extended length and narrative format of our initial comments to "DRAFT 1 – ENERGY STAR Program Requirements for Imaging Equipment (Version 1.1)". Given our concerns with DFE ENERGY STAR testing it was believed the above format was best, compared to the standard "change paragraph to …" format. I would like to offer one last point in closing. Under the current ENERGY STAR Imaging Equipment Specification, EFI was not able to find any category under which our Fiery Server products could obtain ENERGY STAR certification. Specifically, the present ENERGY STAR Imaging Equipment specification does not provide criteria for establishing DFE ENERGY STAR eligibility (i.e., both Imaging Specification related test procedure documents provide procedures for measuring DFE power but the Imaging Specification itself does not provide a metric for determining whether a DFE passes), therefore in accordance with section 3 of the Imaging Specification, the "ENERGY STAR Program Requirements for Computers: Version 4.0" becomes the DFE's governing document. Now the Computer Specification clearly states (Page 8, Section 2, "Qualifying Products") that Mid-Range and Large Servers (as defined in Section 1F) are not covered. In Section 1F, one of the Mid-Range and Large

Server criteria is as follows: “Placed on the market as a Class B product; but hardware upgraded from a Class A product, per EuroNorm EN55022:1998 under EMC Directive 89/336/EEC and designed capable of having a single or dual processor capability (1 or greater sockets on board).” At present, all EFI Fiery Servers contain motherboards whose major components (e.g., memory controller, I/O controller, etc.) are designed and marketed by their manufacturer for use in Class A computer servers. EFI has added shielding and other circuitry/components to make these Class A system designs meet Class B emission criteria. Now because the Computer Specification explicitly excludes Class A hardware that has been modified to meet Class B EMC criteria, the Fiery Server does not fall into any ENERGY STAR certifiable category (i.e., no category exists for which EFI can obtain ENERGY STAR certification for its Fiery Server DFE). With the new ENERGY STAR Computer Specification the classification that prevented EFI from obtaining ENERGY STAR certification for our Fiery Server is removed; but we now face a number of new challenges as outlined above. EFI over the last few years has ensured that all of our Fiery Server products contain efficient power supplies and support ACPI S3 even though it didn’t matter from an ENERGY STAR point-of-view. We believe that our DFE systems will meet ENERGY STAR provided they are tested in the correct category. I look forward to working with you and the ENERGY STAR team/stakeholders to help create the best possible imaging equipment specification. Should you or any member of the ENERGY STAR team have any questions concerning the material presented; please do not hesitate to contact me either by email or telephone and I will try and answer them as quickly as possible.