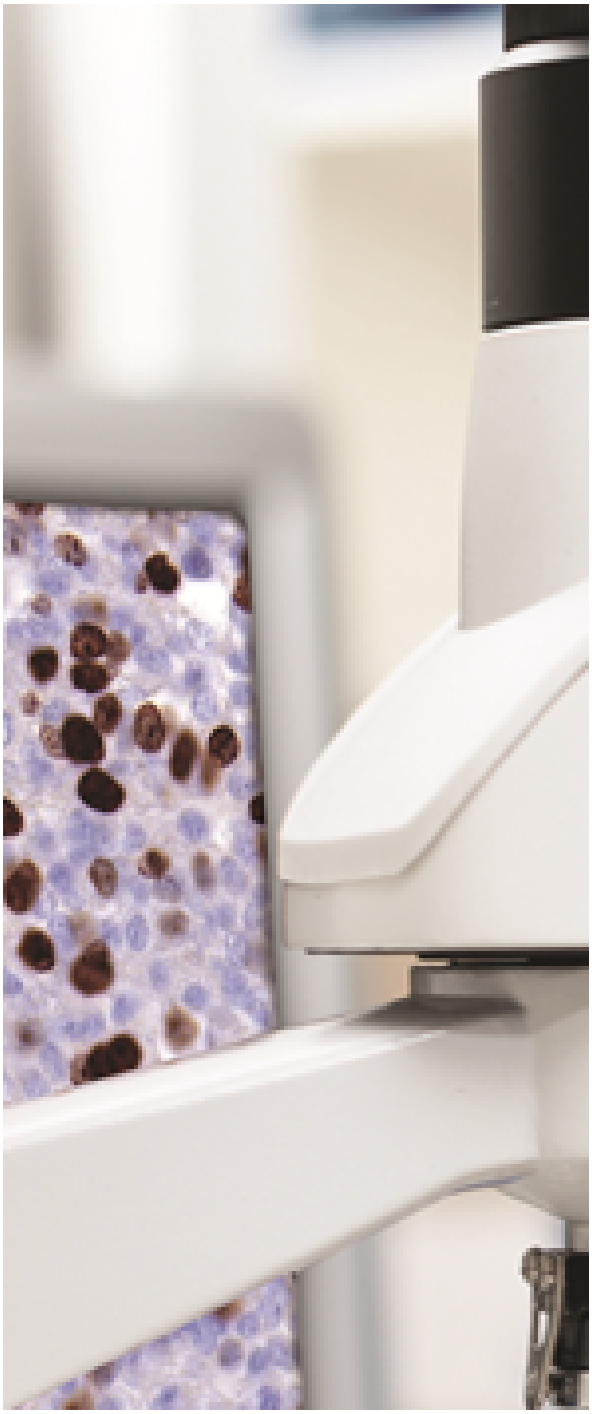

The Pathomation platform: system requirements

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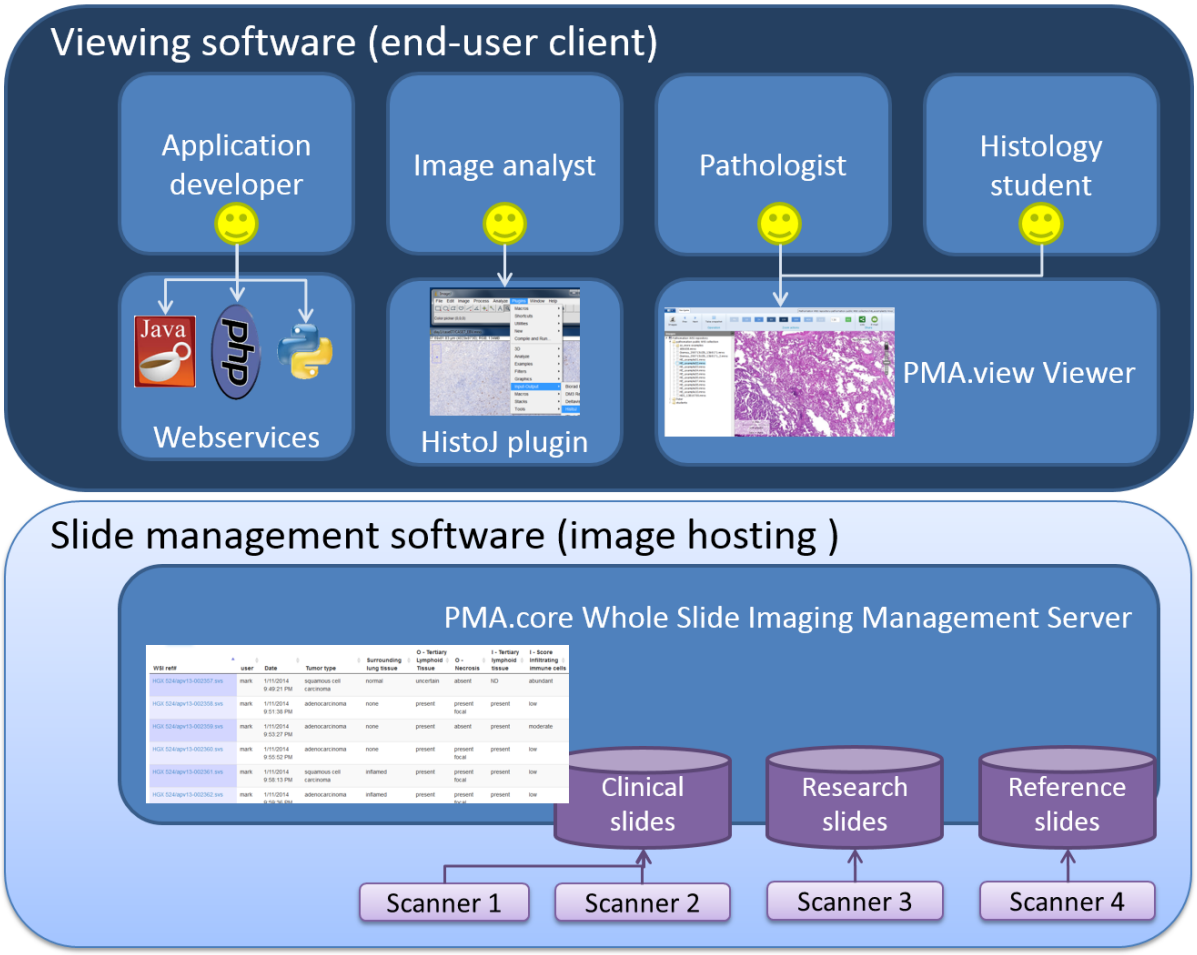
1 Introduction

The Pathomation Software Platform for Digital Pathology ("the platform") offers a rich toolkit of different software components to implement your own customized digital pathology solution.

Pathomation offers a comprehensive platform for vendor-agnostic manipulation of whole slide image data in digital pathology. It contains all the client and server software needed to represent any digital slide image in a fully-automated (or, if so desired, manual) way.

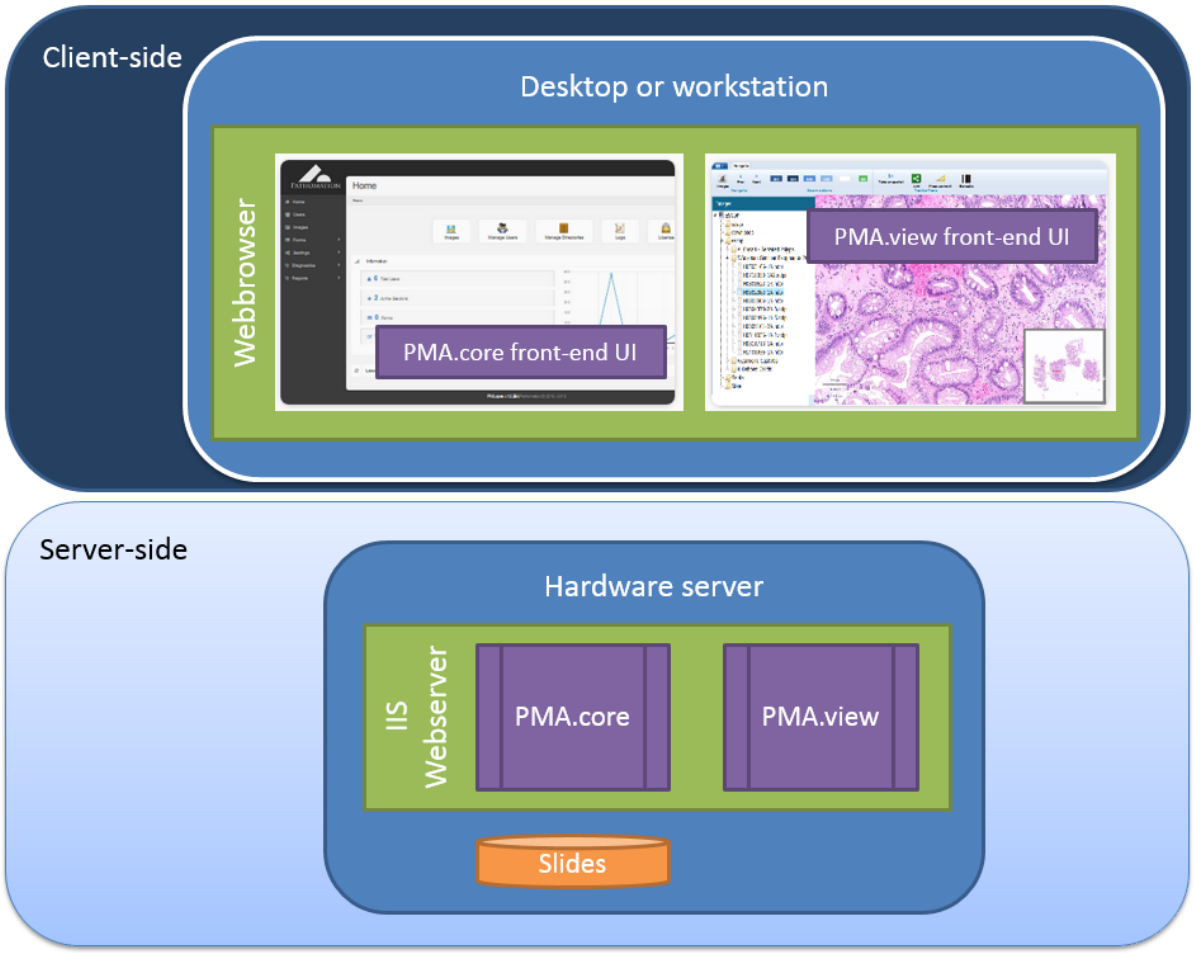
The client software (PMA.view, as well as a number of plugins for vaious hosting environments) is installed based on the requirements of your particular usecase and supports the needs and skills of different users in an organization. The server software, known as PMA.core, is an image rendering abstraction layer and processing environment that allows for the device- and vendor-independent representation of image data. Images are typically streamed to the client components as sets of tiles. PMA.core is capable of handling tens, hundreds or many thousands of images and tiles on a single server.



2 Scenarios

Below we illustrate two different scenarios to deploy our software. The details of these will vary depending on your specific needs, but can still be distilled from the information given herein.

2.1 Single server

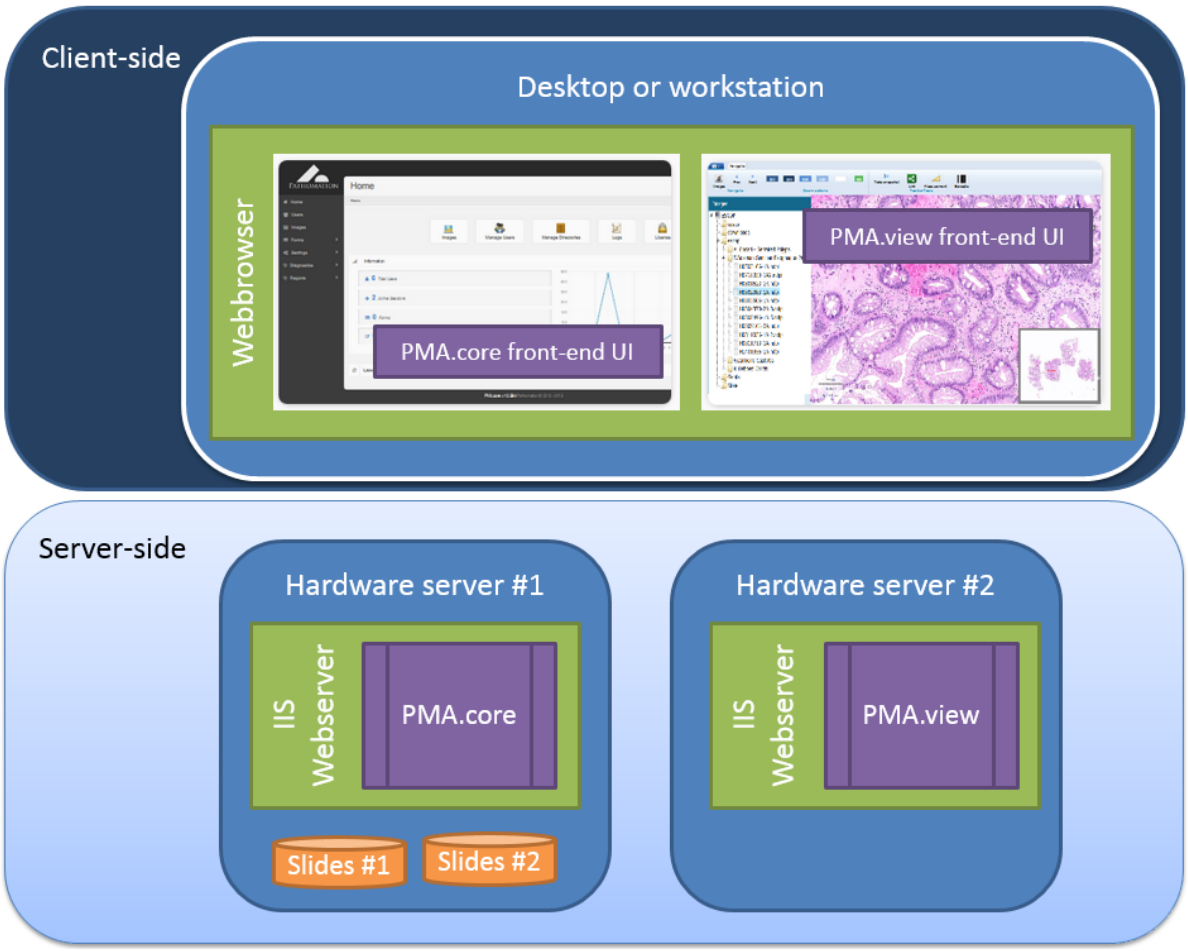


A single piece of hardware is used as a server to run the IIS webserver software, which in turn hosts both PMA.core and the downstream viewing application PMA.view. A single slide repository is available on this machine as well.

Both PMA.core and PMA.view have a front-end user interface (UI). This front-end can be accessed via any computer in the organization's network, or even via the Web (possibly after establishing a VPN to the organization's internal LAN first).

As PMA.core and PMA.view run on the same server hardware, requirements can be summed up as "the maximum of the two". The hosting of PMA.core requires more resources than PMA.view, but when both application are placed on the same hardware, PMA.core requirements should suffice to host both.

2.2 Two servers



Two pieces of server hardware are available in this setup and both run the IIS webserver software. The server that hosts PMA.core also serves as a file server with two slide repositories.

Both PMA.core and PMA.view have a front-end user interface (UI). This front-end can be accessed via any computer in the organization's network, or even via the Web (possibly after establishing a VPN to the organization's internal LAN first). The only difference with the previous setup is that PMA.core will be accessible through http://server1/..., while PMA.view will be accessible through http://server2/...

As PMA.core and PMA.view run on the different server hardware, they can have different resources. The hosting of PMA.core requires more resources than PMA.view, so server #2 need not have as many resources as server #1.

3 System Requirements

The platform consists of a web application and an optional system service for cache scheduling. The software is built for the Microsoft Windows platform and is capable of running in both user and server versions of Windows.

The user interface for our software runs in a webbrowser. Clients are therefore expected to be able to interact with our system in almost any major modern browser with JavaScript enabled on any modern Mac, PC (Windows or Linux). We offer only limited support on mobile platforms for the moment, and features may only be expected to work to the extend that the mobile browser being used is a successful port of its own desktop version.

Requirements and recommendations are given under the assumption that a machine is used for a single purpose only. If you're using a hardware server as a hosting environment for PMA.core as well as a file server for your digital slides, your network bandwidth requirements e.g. will be significantly higher than if you only used it for hosting PMA.core.

Please be aware that system load and performance depend highly on your particular use case for digital pathology. There is a significant difference between hosting a static collection for a high number of concurrent users (typical in an educational setting) or hosting a high-turnover collection that is only consulted by a limited number of pathologists. As it is, we make several recommendations on how you can tune your setup for your particular working conditions.

3.1 Client-side

During development our software is continuously tested on the Microsoft Windows Operating System using the following browsers: Internet Explorer 10+ and the latest versions of Google chrome, Safari and FireFox.

3.1.1 Desktop or workstation hardware

The minimum requirements in terms of processor speed and memory (for end-users) are hard to determine. We are pretty sure that every computer younger than 5 years will be able to interface with the platform using a webbrowser without any problems. In case of doubt, we refer to the particular system requirements that apply to the specific version of flavor of webbrowser that is being used.

3.1.2 Webbrowser

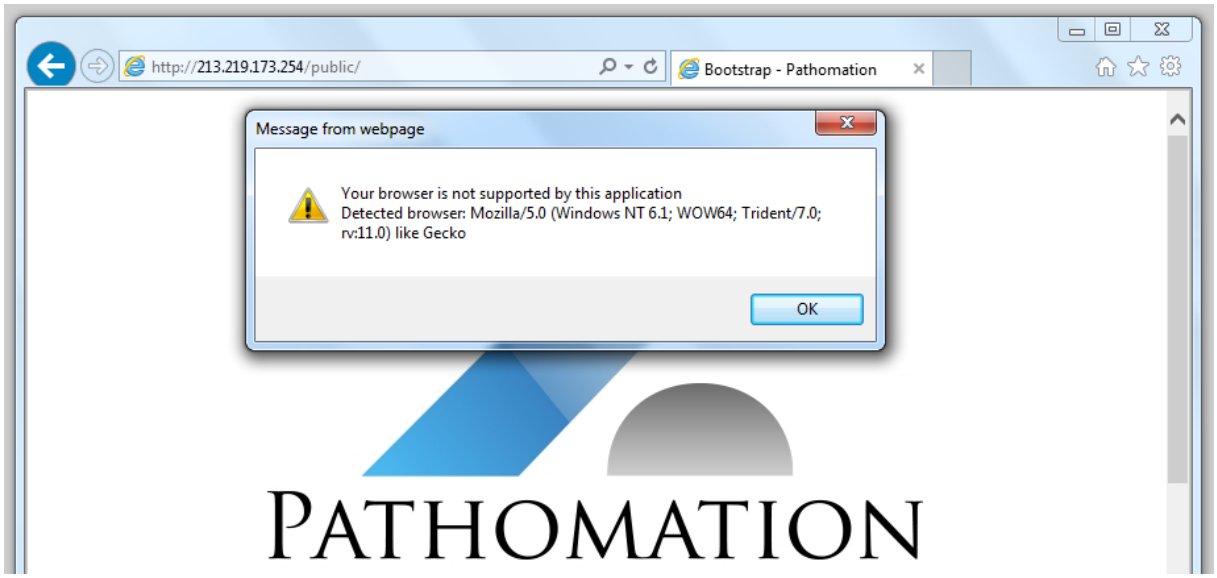
A hosted web application is consulted through a (usually) remote computer on the internal company network (or Internet). To allow the delivery of content to as many clients as possible, we have very relaxed requirements in terms of client hardware and software requirements.

Key is that we don't require any additional webbrowser-plugins such as Flash, Silverlight, WebGL, or Java.Nor do we depend on or do we install any additional browser add-ons (BHO - Browser Helper Objects) ourselves.

You will need a modern HTML5-capable webbrowser. This means that your browser must be configured to allow JavaScript and accept cookies. Besides that, we've tested our software extensively on a host of different webbrowser environment, and found it to operate under almost all, except Internet Explorer 9 or

lower. For the best user experience, we recommend using Mozilla FireFox or Google Chrome. On a Mac, you are welcome to use either FireFox or Safari.

When a browser is not supported, an error message follows.



Because of content delivery through a webbrowser, interfacing with our software is not limited to Windows-only machines (though the web applications themselves run on Microsoft infrastructure). Our communication implementation is based on SOAP webservices and the standard HTTP protocol, so you can truly use our software from anywhere, any time.

3.1.2.1 Popup-blocking and Ad-blocking

Our software uses dialogs as a means to interact with the end-user. These dialogs are implemented based on "best practice" industry standards (including libraries such as Kendo and JQuery). These dialogs are not pop-ups, and during testing, no interference with known pop-up blockers was ever observed.

That being said, it is possible that at some point in the future these pop-up blockers pick up features in our site and label them as popups, subsequently rendering them ineffective. If this happens, you should let us know and we will help resolve the issue in collaboration with you popup blocking software vendor.

The same reasoning applies to webbrowser plugins that block advertisements. These oftentimes already target the kind of technology that we use ourselves to interact through dialogs (such as iframes). There is a large variety of possible interpretations of such features (in a website), and while we haven't come across this yet, it is possible that at some point a certain feature of our site gets interpreted as commercial content. If this happens, you should let us know and we will help resolve the issue in collaboration with you advertisement blocking software vendor.

If you experience problems on your installation, please let us know and we will find a solution to resolve your particular issues.

3.1.3 Supported hosting applications

Our platform offers optional plugins for various host applications such as Adobe Photoshop and ImageJ. The system requirements for these external applications are to be specified by their respective vendors. We don't place additional demands on top of the standard manufacturer's recommendations.

As a rule of thumb, when our PMA.view web-based viewer client is performing well on a user's computer, it can be expected that the plugin for the host application under consideration will perform equally well.

3.2 Server-side

Note that the platform consists of the PMA.core (server-side) web application and the PMA.view (end-user; client-side) viewer web application. Both can be installed side by side as different web applications on the same server. We actually recommend this setup initially, since the viewer web application was designed to have a very small footprint (thin server / fat client concept).

3.2.1 Server hardware

For an initial setup of PMA.core (adequate to serve most conditions) we recommend the folllowing:

Component	Minimum	Suggested
CPU	2.2 GHz Quad Core or AMD equivalent	Intel® Core™ i5-4200H 3.40 GHz or AMD equivalent
RAM	8GB DDR3	16GB DDR3
Hard Disk	SATA II	SATA III SSD for Operating System
Network bandwidth	100 Megabit	1 Gigabit

In a subsequent phase, PMA.view may be installed on a separate machine (see Two server scenario). As the heavy work is done by PMA.core, the specific requirements are significantly less:

Component	Minimum	Recommended
CPU	Intel i3 3220 or AMD FX-4300	Intel i7-47xx or AMD FX
RAM	8GB	16GB
Hard Disk	SATA II	SATA III
Network bandwidth	100 Megabit	1 Gigabit

3.2.2 Operating system and software prerequisites

In principle any version of Windows + Internet Information Server (IIS) will do. We've got the software to run on IIS Express edition for demonstration purposes. We offer the following formal guidelines:

Component	Minimum	Suggested
Operating System	Windows 2008 Server	Windows 2016 Server
Web Server	IIS 7.5	IIS 10.0
.Net framework	4.5	4.7
SQLCE (only for PMA.view)	SQLCE 4.0	SQLCE 4.0
RDBMS (only for PMA.control)	Microsoft SQL Server 2012 Express	Microsoft SQL Server 2017 Express
Visual C++ redistributable package	Visual C++ redistributable package 2015	Visual C++ redistributable package 2015

If want want either software component of the platform to interact with end-users through email, you will also need to provide an SMTP-server. This server may be running over SSL, and does not need to be installed on the same machine as the Pathomation software.

Are you're setting up prerequisites, you should install software in the following order of events:
1. Internet Information Server
2. Microsoft .Net framework
3. SQLCE
4. Microsoft SQL Server
5. Visual C++ redistributable package

3.3 Configuration hints and scaling considerations

Improving disk I/O throughput

The system's response time can be greatly improved by installing it on a solid state disk. The cache directory should also be kept on an SSD as well. Thus an optimal setup would be to install the operating system and the application on an SSD while storing digital slides in regular hard disks (or network shares). Do not underestimate the importance of the regular disks' performance, where slides are stored, though. Whenever possible use 6Gbit SATA III disks.

Network

Multiple NICs may be installed onto the server machine to increase network bandwidth. The system can utilize multiple IP addresses or host names out of the box, thus special load balancing configurations are not required.

Parallel processing

The system is built to process requests in parallel and its performance depends on the available cores per processor, the performance per core, as well the total number of processors in the system. In environments with more than 50 simultaneous users, two processors should at least be available in the system.

4 Performance

We have profiled PMA.core for a variety of conditions

4.1 Network transfer

We have profiled the PMA.core to examine its performance characteristics in a networked environment.

The tests were done using the following hardware
- Server: Intel i5 @ 3GHz, 8GB RAM, 128GB SSD, 1TB SATA III
- Gigabit Ethernet
- 802.11g (64MBps) WiFi - a relatively cheap WiFi router bought off the shelf

Measurements using tile quality 75 and tile size 512x512:

Network type	Tile source	Cache building	Performance	Limit source	Concurrent users*
Gigabit Ethernet	Cache on SSD	No (already built)	1000 tiles/sec	CPU	100
Gigabit Ethernet	Native slides on SATA disk	No (bypass cache)	300 tiles/sec	CPU	30
Gigabit Ethernet	Native slides on SSD disk	No (bypass cache)	400 tiles/sec	CPU	40
Gigabit Ethernet	Native slides on SATA disk	Yes (cache build on SSD)	200 tiles/sec	Disk	20
Gigabit Ethernet	Native slides on SSD disk	Yes (cache build on SSD)	300 tiles/sec	Disk	30
WiFi 54Mbps	Cache on SSD	No (already built)	150 tiles/sec	Network	15
WiFi 54Mbps	Native slides on SATA disk	No (bypass cache)	150 tiles/sec	Network	15
WiFi 54Mbps	Native slides on SSD disk	No (bypass cache)	150 tiles/sec	Network	15
WiFi 54Mbps	Native slides on SATA disk	Yes (cache build on SSD)	150 tiles/sec	Network	15
WiFi 54Mbps	Native slides on SSD disk	Yes (cache build on SSD)	150 tiles/sec	Network	15

* Concurrent users is an estimation based on the following assumption: Given a slide of 100,000 x 210,000 pixels (x20 scan) we assume that a user will view 3% of it in period of 5 minutes. Such an image has about 100,000 tiles, thus the user will request 3,000 tiles (3%) in 5 minutes or 300 seconds. This translates to 10 tiles per second per user on average.

Dropping tile quality to 50 improved performance over WiFi to 280 tiles per second.

4.2 File format comparison

Test method

An in-house built profiler tool has been used to test the performance of the various whole slide image formats supported by PMA.core. The measurements were performed on each sample slide separately,

without any cache being available and without creating additional cache during the tests (i.e. cache was totally disabled).

The used sample slides were not always exactly the same across different formats, but similar in dimensions at the extent possible. All of them were encoded in JPEG. 10 simultaneous requests were used for each image.

Server configuration

Hardware & Software	
CPU	Intel i5-3330 @ 3.00GHz
RAM	8GB
HDD	SATA III @ 7200 RPM
Network	Gigabit Ethernet
Operating System	Windows 8 Pro
Web Server	IIS 8
PMA.core	Release x64 version

Results

Format	Parser	Dimensions (pixels)	Test run time (hh:mm:ss)	Bytes downloaded	Tiles downloaded	Tiles / sec	AVG tile fetch time (sec)
BIF	HistoscopeLib	105948 x 94154	00:02:31	501.74 mb	11767	77.494	0.118
CZI	ZeissImageLib	86757 x 83456	00:01:29	461.32 mb	8068	90.462	0.095

MRXS	OpenSlide	100560 x 211656	00:01:33	504.83 mb	19667	211.4	0.037
NDPI	HistoscopeLib	122880 x 110592	00:05:22	500.41 mb	13580	42.105	**0.227**
SCN	HistoscopeLib	41950 x 60624	00:00:38	458.71 mb	8301	215.14	0.036
SVS	HistoscopeLib	46000 x 32914	00:00:31	183.62 mb	7755	244.14	**0.030**
VSI	HistoscopeLib	77231 x 130363	00:03:29	501.18 mb	31781	151.81	0.055
Huron	HistoscopeLib	78490 x 94715	00:00:41	507.42 mb	7434	178.7	0.046

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