

The logo for EaaS! is located in the upper left corner. It consists of the text "EaaS!" in a white, sans-serif font. The "i" is stylized with a blue dot and a vertical blue bar. The logo is partially enclosed by a grey circular shape that overlaps with a larger white circle in the background.

EaaS!

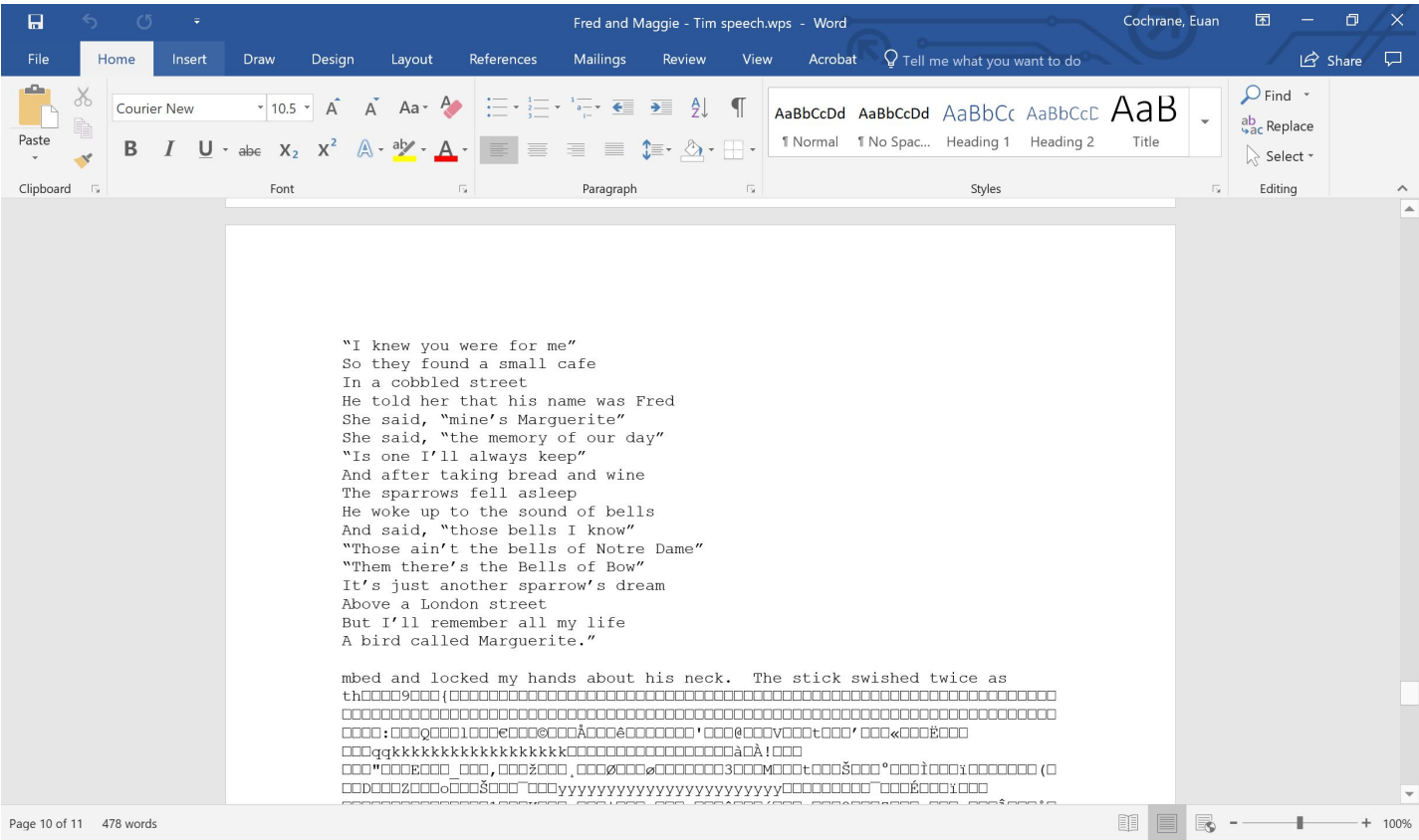
TOWARDS A UNIVERSAL VIRTUAL INTERACTOR (UVI) FOR DIGITAL OBJECTS

Yale University Library
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Seth Anderson
Ethan Gates

Open SLX GmbH
Klaus Rechert (P)

Educopia Institute
Jessica Meyerson

Demo



Demo

Environments

Virtual machines

Object Environments

Containers

Search...

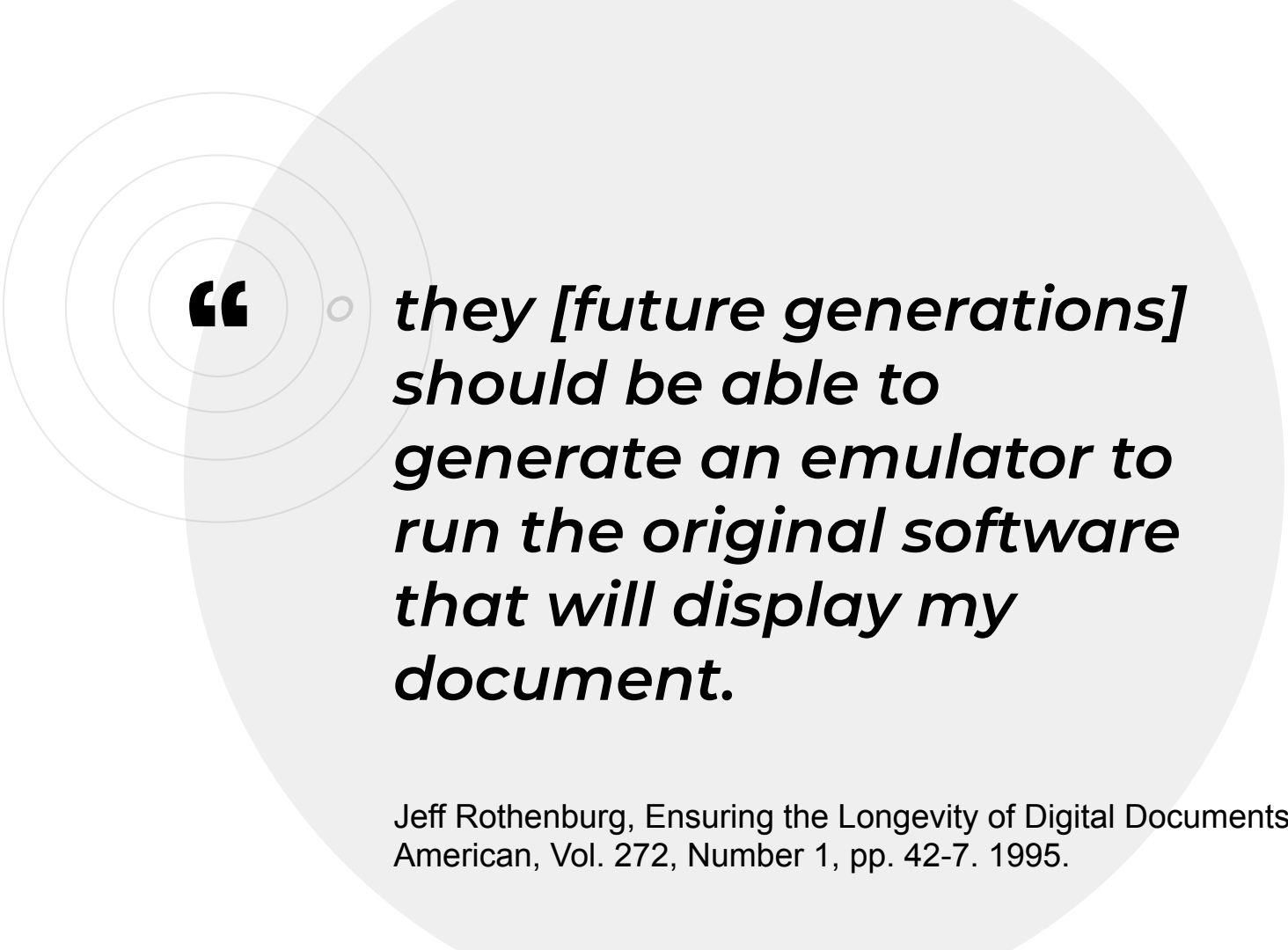
Windows 98 SE - Autoboot to Works Document

[\[Run\]](#) [\[Edit description\]](#) [\[Delete\]](#) [\[Add software\]](#)

A series of four concentric circles in a light gray color, centered on the left side of the slide.

Overview

- Demo
- Background/History
- EaaS
- UVI

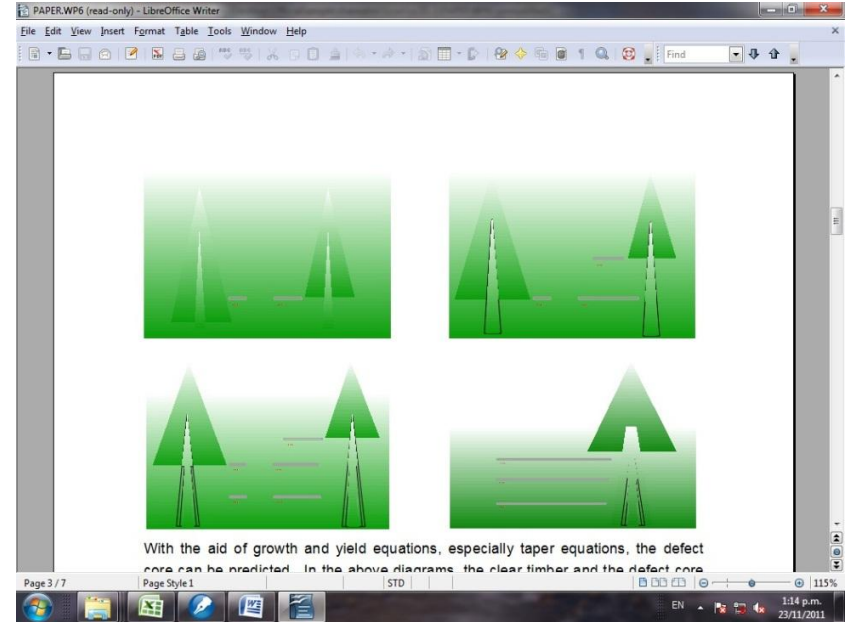
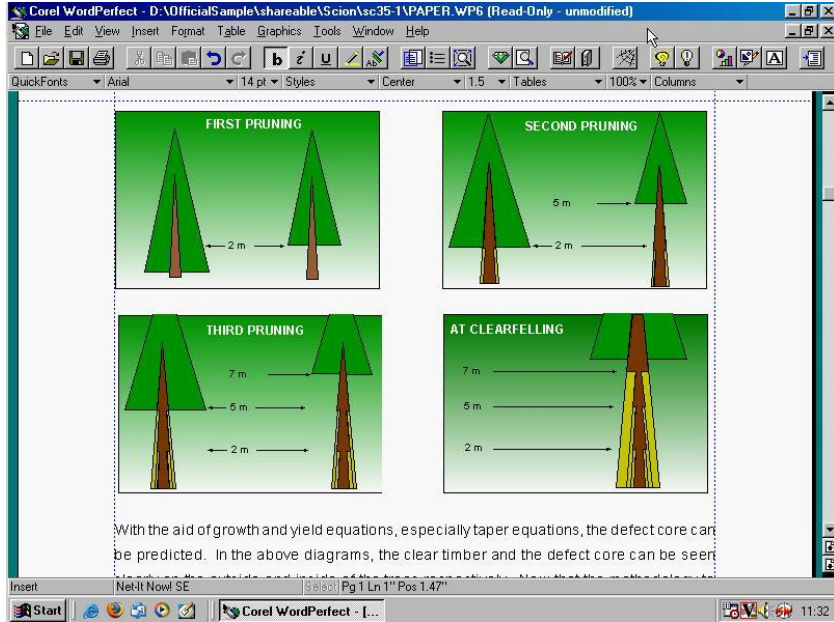


“

*they [future generations]
should be able to
generate an emulator to
run the original software
that will display my
document.*

Jeff Rothenburg, "Ensuring the Longevity of Digital Documents", Scientific American, Vol. 272, Number 1, pp. 42-7. 1995.

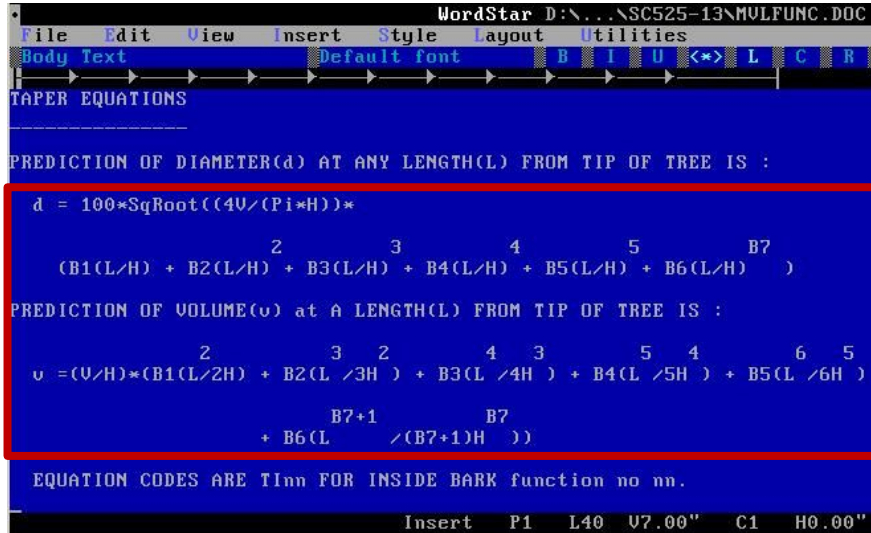
Users need the option to interact with objects in original software



Original content in original software
(WordPerfect in Windows 95)

Original content in newer software
(LibreOffice Writer in Windows Vista)

Research results are at risk of loss



```

WordStar D:\...\SC525-13\MULFUNC.DOC
File Edit View Insert Style Layout Utilities
Body Text Default font B I U <*> L C R
TAPER EQUATIONS
-----
PREDICTION OF DIAMETER(d) AT ANY LENGTH(L) FROM TIP OF TREE IS :

d = 100*SqRoot((4V/(Pi*H))*
      2      3      4      5      B7
      (B1(L/H) + B2(L/H) + B3(L/H) + B4(L/H) + B5(L/H) + B6(L/H) ) )

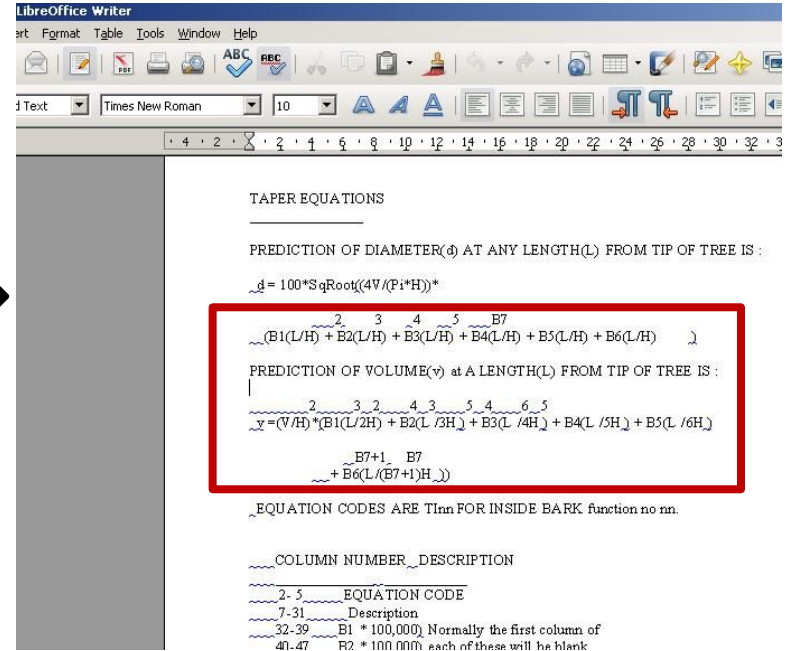
PREDICTION OF VOLUME(v) at A LENGTH(L) FROM TIP OF TREE IS :

v =(V/H)*(B1(L/2H) + B2(L /3H ) + B3(L /4H ) + B4(L /5H ) + B5(L /6H )
      B7+1      B7
      + B6(L / (B7+1)H ))

EQUATION CODES ARE Tinn FOR INSIDE BARK function no nn.
Insert P1 L40 V7.00" C1 H0.00"
    
```

Original content in original software
(WordStar for DOS in Microsoft DOS)

[NB: equation predicting tree growth rates
includes exponents documented using
upper line of text]



```

LibreOffice Writer
File Format Table Tools Window Help
Text Times New Roman 10
TAPER EQUATIONS
-----
PREDICTION OF DIAMETER(d) AT ANY LENGTH(L) FROM TIP OF TREE IS :

_d = 100*SqRoot((4V/(Pi*H))*
      2      3      4      5      B7
      (B1(L/H) + B2(L/H) + B3(L/H) + B4(L/H) + B5(L/H) + B6(L/H) ) )

PREDICTION OF VOLUME(v) at A LENGTH(L) FROM TIP OF TREE IS :

_v =(V/H)*(B1(L/2H) + B2(L /3H ) + B3(L /4H ) + B4(L /5H ) + B5(L /6H )
      B7+1      B7
      + B6(L / (B7+1)H ))

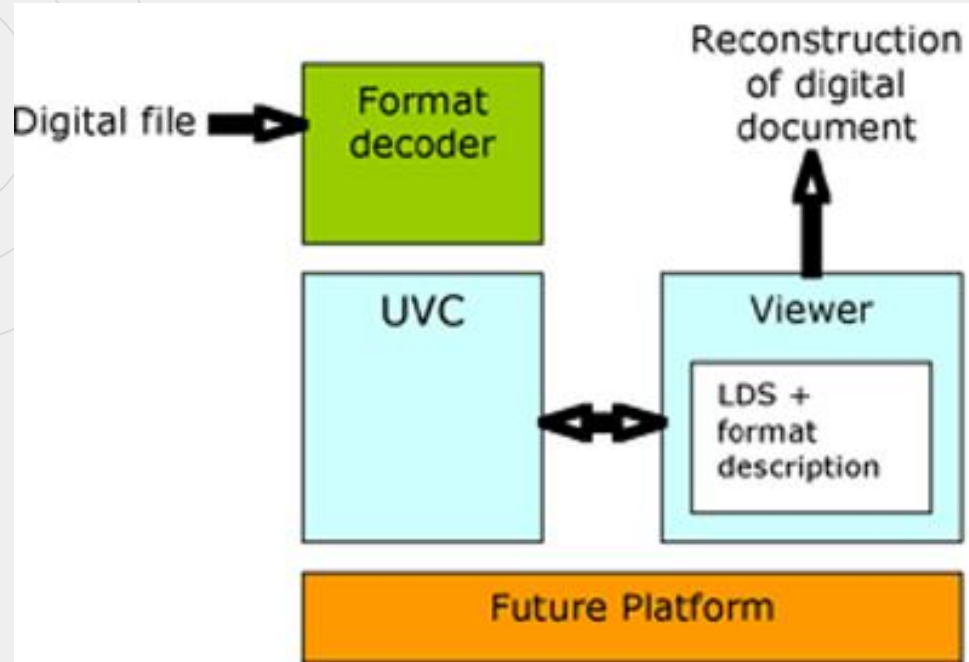
_EQUATION CODES ARE Tinn FOR INSIDE BARK function no nn.

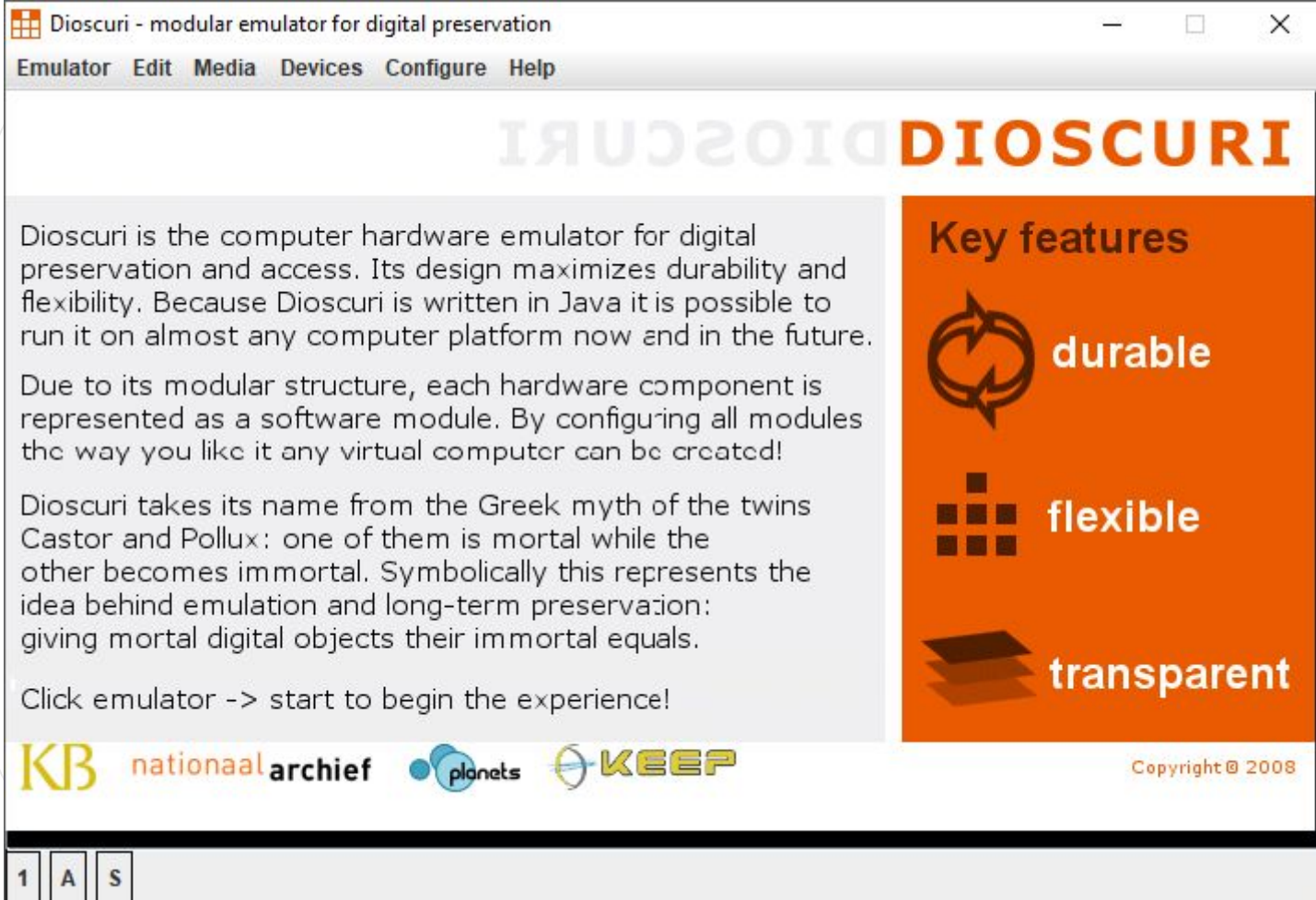
COLUMN NUMBER DESCRIPTION
2-5 EQUATION CODE
7-31 Description
32-39 B1 * 100,000 Normally the first column of
40-47 B2 * 100,000 each of these will be blank
    
```

Original content in newer software
(LibreOffice Writer in Windows Vista)

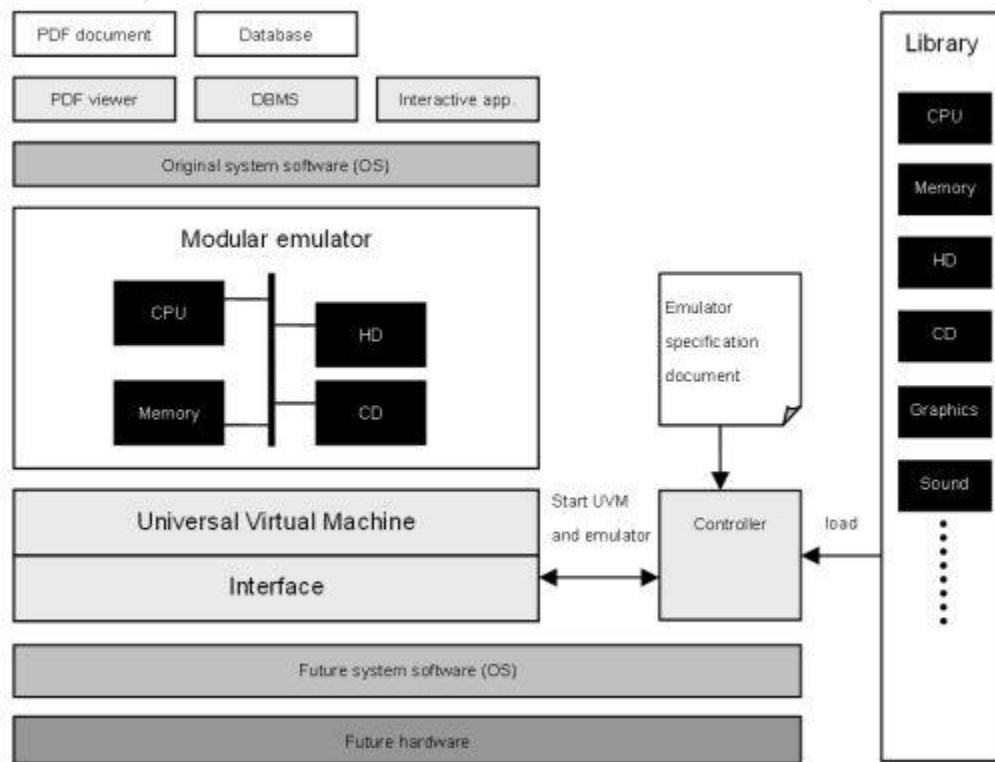
[NB: equation layout and meaning changed]

The Universal Virtual Computer (UVC)





Dioscuri Modular Emulator Design



Keeping Emulation Environments Portable (KEEP)

1

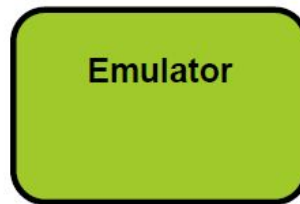
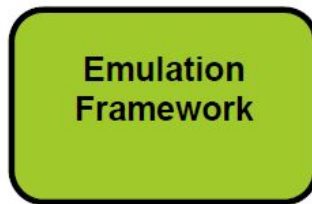
When a user requests an item from a digital collection and this item requires an old computer environment to render, the Emulation Framework is used.

2

The Emulation Framework automatically selects and runs the best available emulator and configures the software dependencies required to render the object (operating system, applications, etc.).

3

A virtual screen shows the digital item with original software of that time.



#	FILEFORMAT_ID	FILEFORMAT_NAME	APP_ID	APP_NAME	OS_ID	OS_NAME	PLATFORM_ID	PLATFORM_NAME
---	---------------	-----------------	--------	----------	-------	---------	-------------	---------------

1	FFT-1007	Extensible Markup Language	APP-1000	FreeDOS Edit	OPS-1000	FreeDOS	HPF-1004	x86
2	FFT-1008	Plain text	APP-1000	FreeDOS Edit	OPS-1000	FreeDOS	HPF-1004	x86
3	FFT-1009	JPEG File Interchange Format	APP-1001	Blocek	OPS-1000	FreeDOS	HPF-1004	x86
4	FFT-1010	Windows Bitmap	APP-1001	Blocek	OPS-1000	FreeDOS	HPF-1004	x86
5	FFT-1011	Graphics Interchange Format	APP-1001	Blocek	OPS-1000	FreeDOS	HPF-1004	x86
6	FFT-1012	Tagged Image File Format	APP-1001	Blocek	OPS-1000	FreeDOS	HPF-1004	x86
7	FFT-1013	Portable Network Graphics	APP-1001	Blocek	OPS-1000	FreeDOS	HPF-1004	x86
8	FFT-1009	JPEG File Interchange Format	APP-1002	Xzgv	OPS-1001	Damn Small Linux	HPF-1004	x86
9	FFT-1010	Windows Bitmap	APP-1002	Xzgv	OPS-1001	Damn Small Linux	HPF-1004	x86
10	FFT-1011	Graphics Interchange Format	APP-1002	Xzgv	OPS-1001	Damn Small Linux	HPF-1004	x86
11	FFT-1012	Tagged Image File Format	APP-1002	Xzgv	OPS-1001	Damn Small Linux	HPF-1004	x86
12	FFT-1013	Portable Network Graphics	APP-1002	Xzgv	OPS-1001	Damn Small Linux	HPF-1004	x86
13	FFT-1006	Portable Document Format	APP-1003	Xpdf	OPS-1001	Damn Small Linux	HPF-1004	x86
14	FFT-1030	PDF/A	APP-1003	Xpdf	OPS-1001	Damn Small Linux	HPF-1004	x86
15	FFT-1007	Extensible Markup Language	APP-1004	Beaver	OPS-1001	Damn Small Linux	HPF-1004	x86
16	FFT-1008	Plain text	APP-1004	Beaver	OPS-1001	Damn Small Linux	HPF-1004	x86
17	FFT-1014	Hypertext Markup Language	APP-1005	Firefox	OPS-1001	Damn Small Linux	HPF-1004	x86
18	FFT-1016	Microsoft Word	APP-1006	MS Office Viewer	OPS-1001	Damn Small Linux	HPF-1004	x86
19	FFT-1025	ZIP Format	APP-1014	Info-zip	OPS-1001	Damn Small Linux	HPF-1004	x86
20	FFT-1022	XLS	APP-1007	gnnumeric	OPS-1002	Puppy Linux	HPF-1004	x86
21	FFT-1023	MPEG	APP-1008	mPlayer	OPS-1002	Puppy Linux	HPF-1004	x86
22	FFT-1026	Audio/Video Interleaved Format	APP-1008	mPlayer	OPS-1002	Puppy Linux	HPF-1004	x86
23	FFT-1009	JPEG File Interchange Format	APP-1009	Viewnior	OPS-1002	Puppy Linux	HPF-1004	x86
24	FFT-1010	Windows Bitmap	APP-1009	Viewnior	OPS-1002	Puppy Linux	HPF-1004	x86
25	FFT-1011	Graphics Interchange Format	APP-1009	Viewnior	OPS-1002	Puppy Linux	HPF-1004	x86
26	FFT-1012	Tagged Image File Format	APP-1009	Viewnior	OPS-1002	Puppy Linux	HPF-1004	x86
27	FFT-1013	Portable Network Graphics	APP-1009	Viewnior	OPS-1002	Puppy Linux	HPF-1004	x86
28	FFT-1024	Scalable Vector Graphics	APP-1013	InkItte	OPS-1002	Puppy Linux	HPF-1004	x86
29	FFT-1025	ZIP Format	APP-1014	Info-zip	OPS-1002	Puppy Linux	HPF-1004	x86
30	FFT-1006	Portable Document Format	APP-1015	ePDFView	OPS-1002	Puppy Linux	HPF-1004	x86
31	FFT-1030	PDF/A	APP-1015	ePDFView	OPS-1002	Puppy Linux	HPF-1004	x86
32	FFT-1007	Extensible Markup Language	APP-1000	FreeDOS Edit	OPS-1003	FreeDOS	HPF-1004	x86
33	FFT-1008	Plain text	APP-1000	FreeDOS Edit	OPS-1003	FreeDOS	HPF-1004	x86
34	FFT-1009	JPEG File Interchange Format	APP-1001	Blocek	OPS-1003	FreeDOS	HPF-1004	x86
35	FFT-1010	Windows Bitmap	APP-1001	Blocek	OPS-1003	FreeDOS	HPF-1004	x86
36	FFT-1011	Graphics Interchange Format	APP-1001	Blocek	OPS-1003	FreeDOS	HPF-1004	x86
37	FFT-1012	Tagged Image File Format	APP-1001	Blocek	OPS-1003	FreeDOS	HPF-1004	x86
38	FFT-1013	Portable Network Graphics	APP-1001	Blocek	OPS-1003	FreeDOS	HPF-1004	x86
39	FFT-1025	ZIP Format	APP-1010	FreeDOS ZIP	OPS-1003	FreeDOS	HPF-1004	x86
40	FFT-1018	ARJ archive data	APP-1011	Open-source ARJ	OPS-1003	FreeDOS	HPF-1004	x86
41	FFT-1019	LHarc 1.x/ARX archive data [lho]	APP-1012	LHarc	OPS-1003	FreeDOS	HPF-1004	x86

View-Paths publicly available in the KEEP Framework



Keep limitations

- Each environment had to be configured and documented in each installation
- Few view-paths available out of the box
- Desktop-only software



bwFLA Emulation as a Service (EaaS)

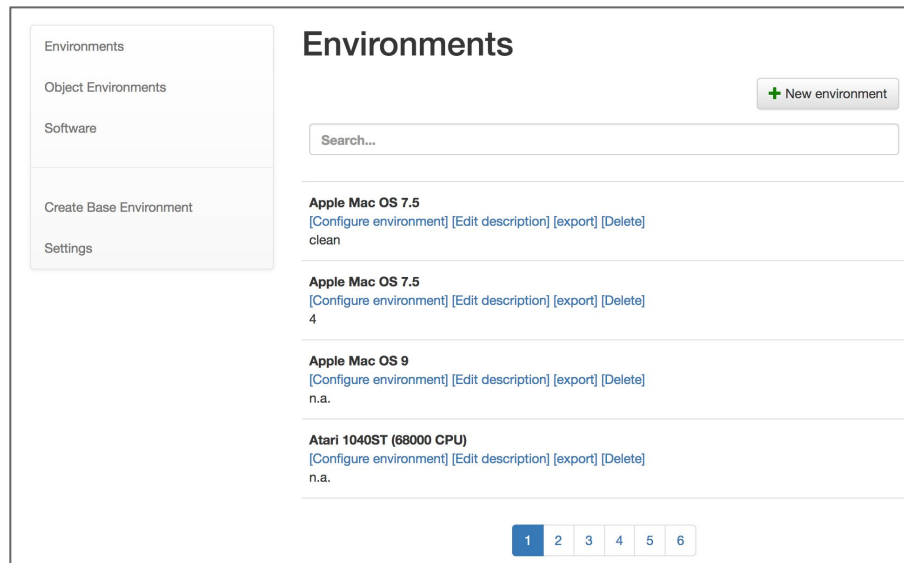


What is Emulation-as- a-Service?

Simplifies access to various emulators



Enables management of persistent, citable emulation environments



Derivatives enable storage savings



"Base"
Environment
(e.g. Windows XP)

5 GB
(Compressed)



Derivative x1
(e.g. Windows XP + SPSS 13)

150MB



Derivative x1.1
(e.g. Windows XP + SPSS 13 + SPSS code)

1MB



Derivative x2
(e.g. Windows XP + STATA 8.2)

250MB



Derivative x3
(e.g. Windows XP+ STATA 8.2 + STATA code)

1MB



Derivative x3
(e.g. Windows XP + R 2.0.0)

50MB

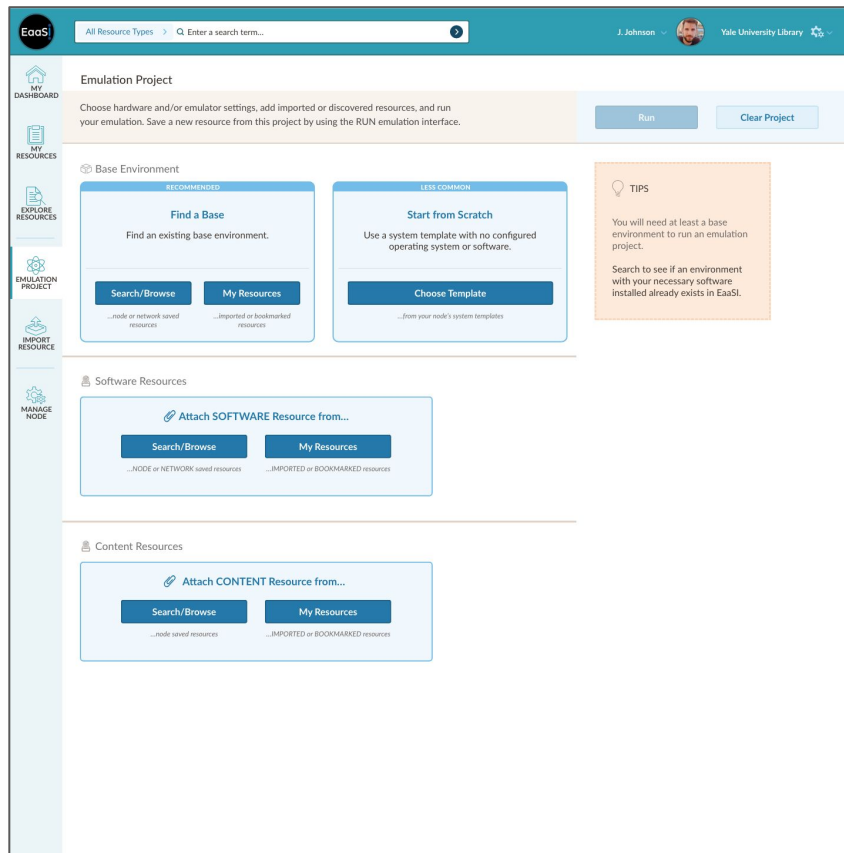
The image features a dark blue background with a bokeh effect of out-of-focus blue circles. Two concentric white circles are centered on the page. The text 'EaaS' is centered within the inner circle, with the 'i' in 'aaS' being a solid blue color.

EaaS



Project Goal

Deploy and scale infrastructure and services for software emulation, including distributed management, sharing, documentation/discovery, and access.



EaaS - Updated UI Wireframe

Distributed Mgmt

- A network of distributed nodes, each contributing to the EaaSI service and the software development roadmap.



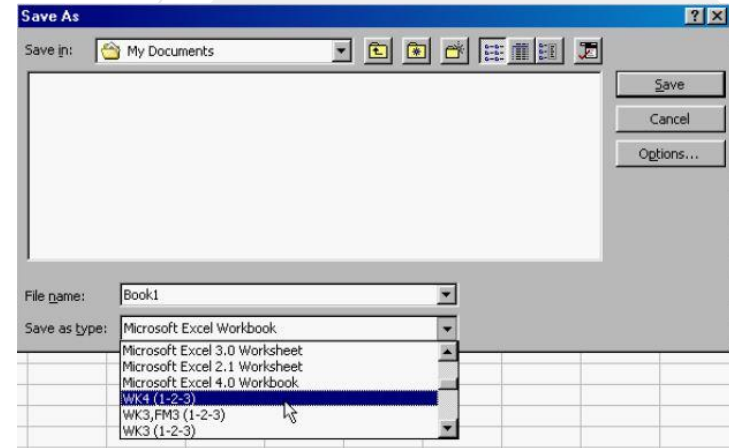
Sharing

- In-network sharing of software images and configured environments.
- Yale University Library is configuring and sharing at least 3000 pre-configured software applications running in configured environments.



Documentation/ Discovery

- Incorporating services developed by Wikidata for Digital Preservation
- Comprehensive, open, machine-readable documentation
- Defining profile for description of software and computer environments



Documentation/ Discovery

Corel Presentations 11 “Open” file operation formats:

Adobe Photoshop bitmap (*.psd), AutoCAD (*.dxf), CALS bitmap (*.cal), CompuServe bitmap (*.gif), Corel PHOTO-PAINT Image (*.cpt), Corel Presentations (*.shw, *.wpg), Corel Presentations Master (*.mst), CorelDRAW File (*.cdr, *.pat), CorelDRAW Template (*.cdt), Encapsulated Postscript (*.eps), Enhanced Windows Metafile (*.emf), Freelance Graphics (*.pre), GEM Paint bitmap (*.img), Harvard Graphics (*.prs, *.ch3, *.sh3, *.sy3, *.tp3), Hewlett-Packard Graphics Language (*.hpg, *.plt), JPEG bitmap (*.jpg, *.jpeg), Kodak Photo CD (*.pcd), Lotus PIC (*.pic), MS PowerPoint (*.ppt), MacPaint bitmap (*.mac), Macintosh PICT (*.pct), Micrografx Designer (*.drw), PC Paintbrush bitmap (*.pcx), Portable Network Graphics (*.png), Scalable Vector Graphics (*.SVG), Scitex CT bitmap (*.sct), TIFF bitmap (*.tif), Truevision Targa bitmap (*.tga), Windows Metafile (*.wmf), Windows bitmap (*.bmp), WordPerfect Document (*.wpd)

Access

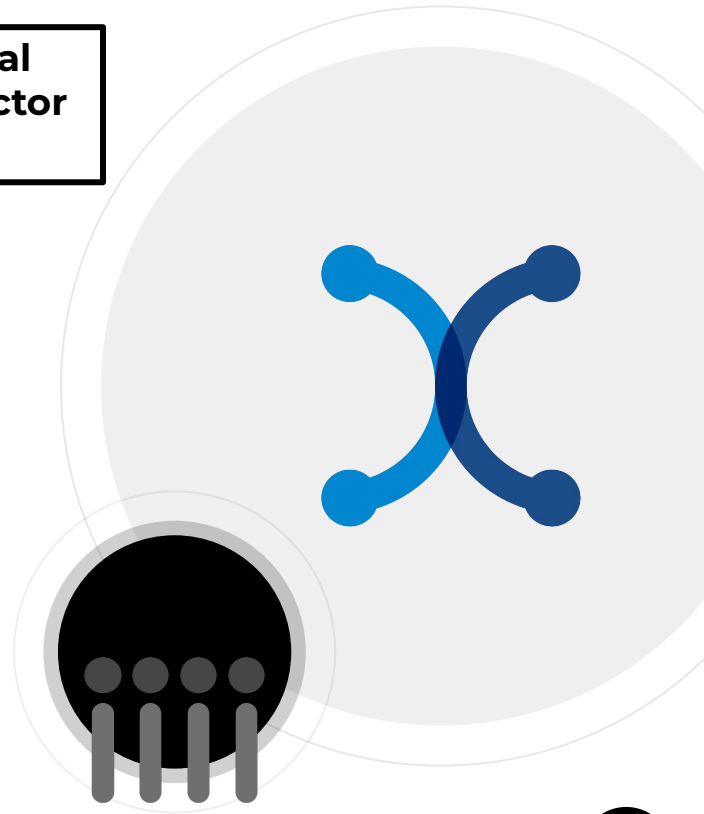
- Emulated CD-ROM environment sharing service
- Virtual Reading Rooms Service
- Scientific Software Portal
- API to automatically render objects in original software via emulation

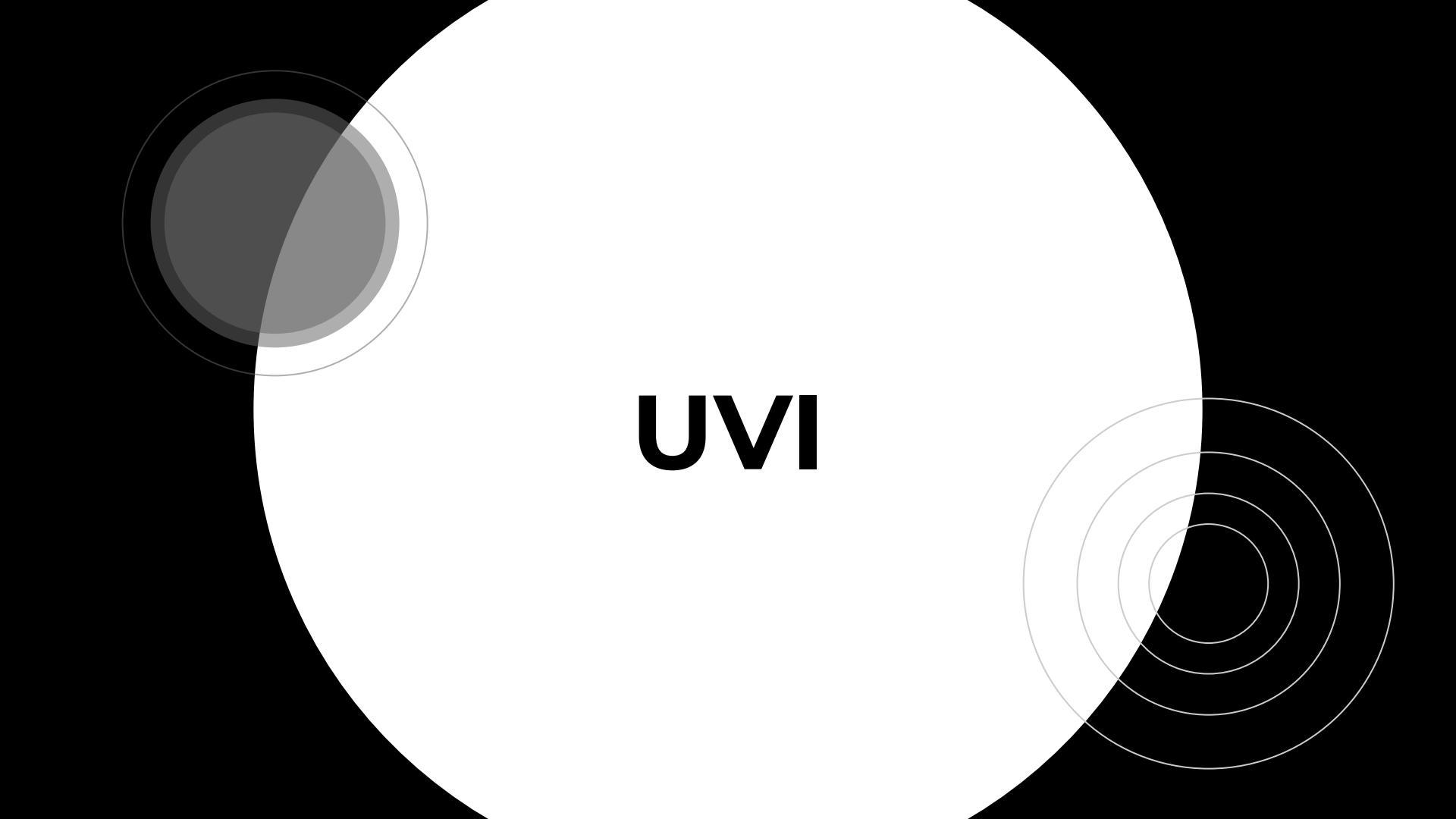


Access

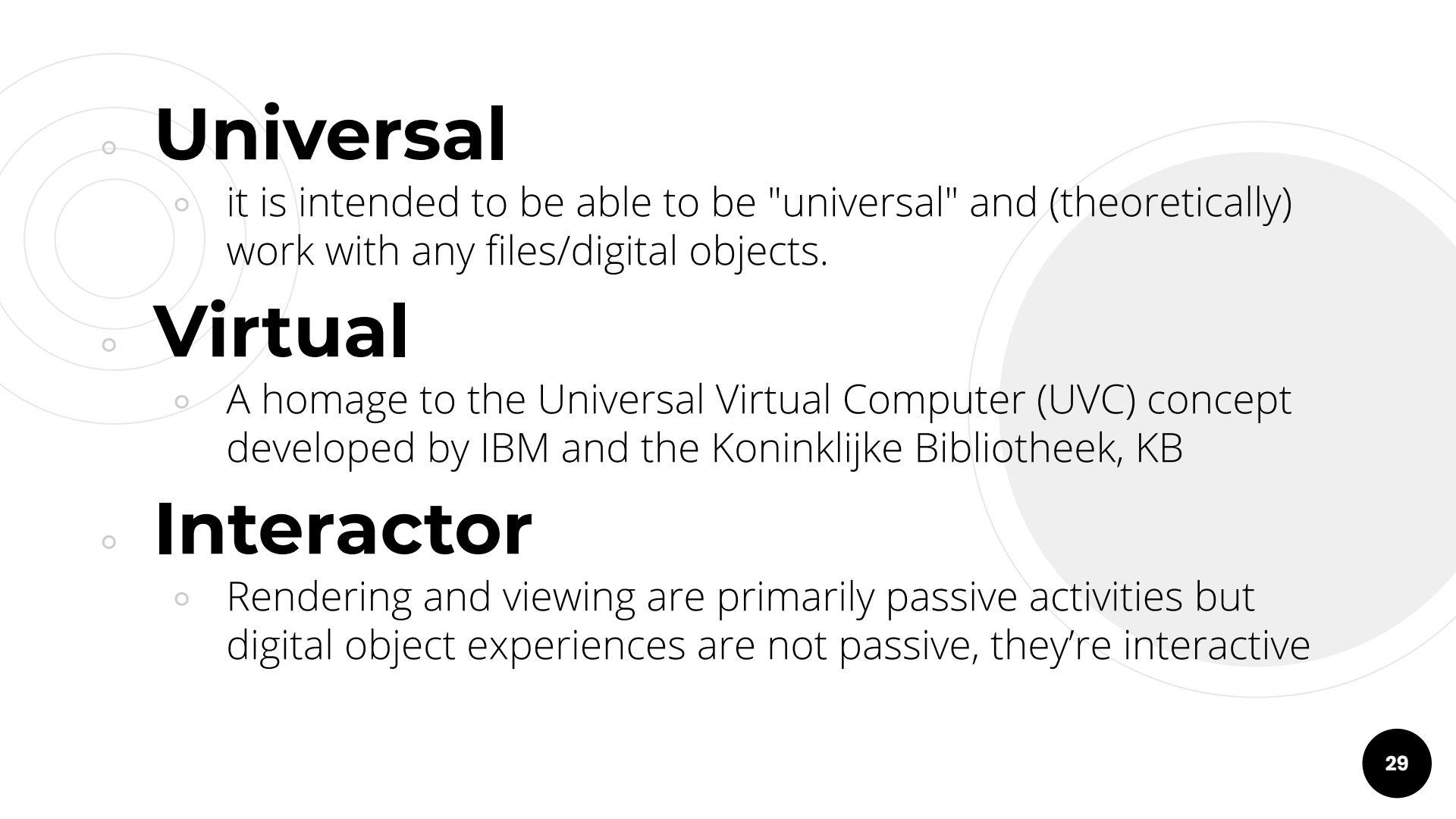
- Emulated CD-ROM environment sharing service
- Virtual Reading Rooms Service
- Scientific Software Portal
- API to automatically render objects in original software via emulation

**The Universal
Virtual Interactor
(UVI)**





UVI



Universal

- it is intended to be able to be "universal" and (theoretically) work with any files/digital objects.

Virtual

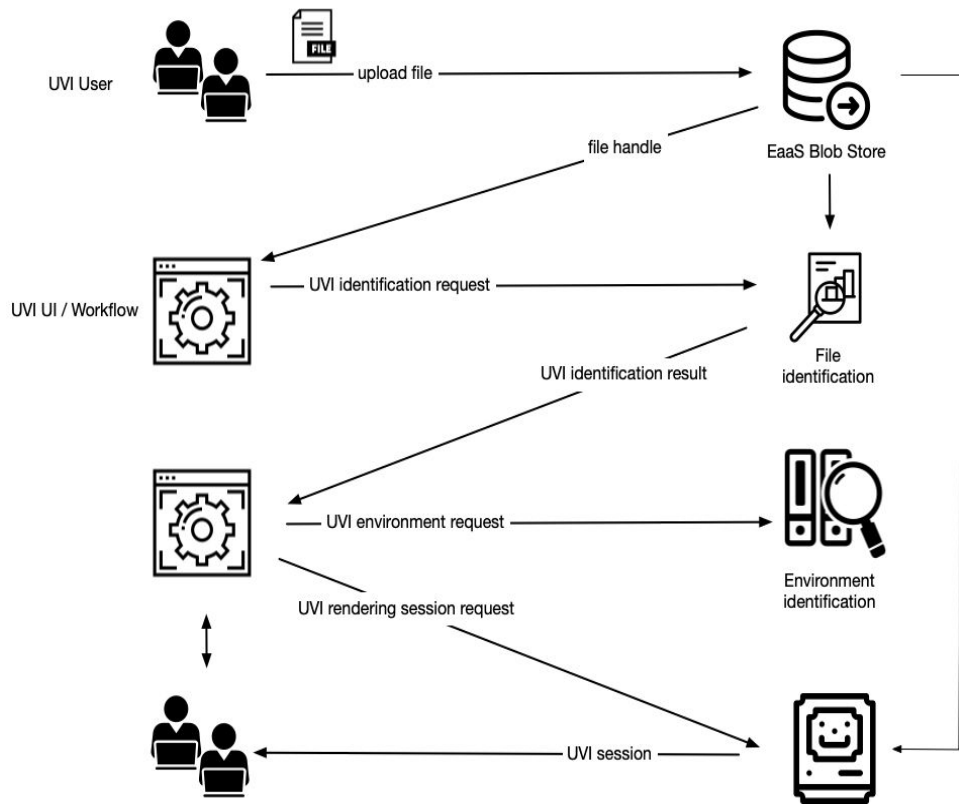
- A homage to the Universal Virtual Computer (UVC) concept developed by IBM and the Koninklijke Bibliotheek, KB

◦ Interactor

- Rendering and viewing are primarily passive activities but digital object experiences are not passive, they're interactive

UVI Overview

- Upload file
- Identify age and format family
- Extract any useful metadata
- Match to environments and rank “best match” or a hex editor
- Autostart rendering object



Identification

- Identify software to render file
 - □ Siegfried / Droid
- Use file creation/modification date to determine software version
- Better tool support is required to match software (and version)
- Metadata, describing software capabilities

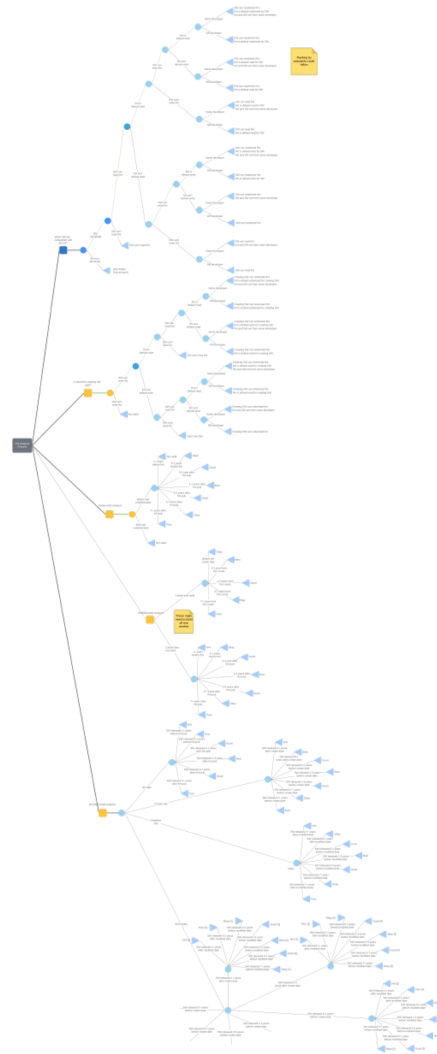


Documentation/ Discovery

Corel Presentations 11 “Open” file operation formats:

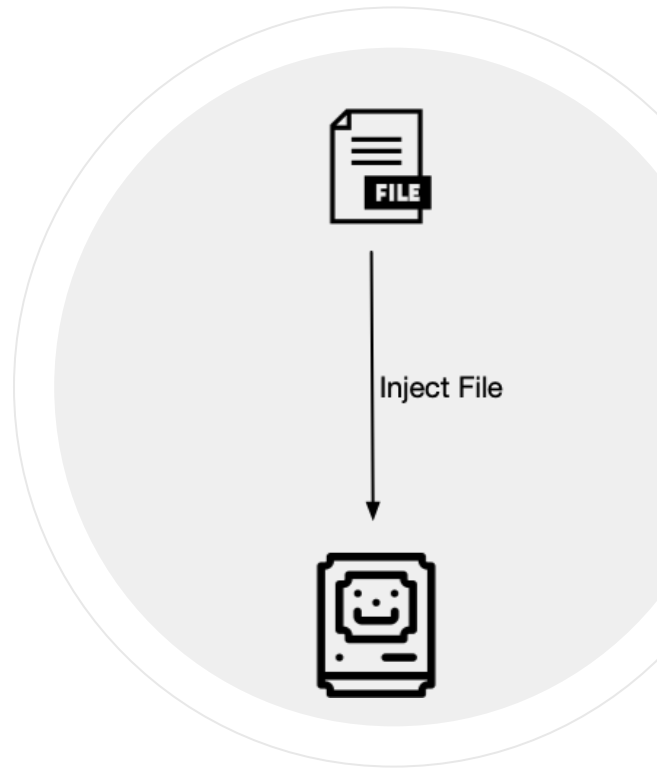
Adobe Photoshop bitmap (*.psd), AutoCAD (*.dxf), CALS bitmap (*.cal), CompuServe bitmap (*.gif), Corel PHOTO-PAINT Image (*.cpt), Corel Presentations (*.shw, *.wpg), Corel Presentations Master (*.mst), CorelDRAW File (*.cdr, *.pat), CorelDRAW Template (*.cdt), Encapsulated Postscript (*.eps), Enhanced Windows Metafile (*.emf), Freelance Graphics (*.pre), GEM Paint bitmap (*.img), Harvard Graphics (*.prs, *.ch3, *.sh3, *.sy3, *.tp3), Hewlett-Packard Graphics Language (*.hpg, *.plt), JPEG bitmap (*.jpg, *.jpeg), Kodak Photo CD (*.pcd), Lotus PIC (*.pic), MS PowerPoint (*.ppt), MacPaint bitmap (*.mac), Macintosh PICT (*.pct), Micrografx Designer (*.drw), PC Paintbrush bitmap (*.pcx), Portable Network Graphics (*.png), Scalable Vector Graphics (*.SVG), Scitex CT bitmap (*.sct), TIFF bitmap (*.tif), Truevision Targa bitmap (*.tga), Windows Metafile (*.wmf), Windows bitmap (*.bmp), WordPerfect Document (*.wpd)

More data enables more accurate matching



Object Preparation

- Choose appropriate media type based on
 - Environment and OS metadata
 - Supported media types
 - Supported filesystems
 - Read-only rendering or writeable



Auto-opening after system boot

- Scale
 - Automate rendering as much as possible
 - Keep environments generic (unmodified)
 - Multipurpose environments
 - Reduce maintenance
- ☐ automation included with user object



Future developments

- Improve automation
- Automate and document SW-related tasks
 - Preserve usage knowledge
 - Automate common tasks
- Work with complex (multi – FFMT data sets)
 - Complex SW setups (RDM)
 - Processing Pipelines



Our Team

- **Euan Cochrane** Principal Investigator
- **Seth Anderson** Program Manager
- **Ethan Gates** Software Preservation Analyst
- **Klaus Rechert & Oleg Stobbe (OpenSLX)** Technical Architecture and Development
- **PortalMedia** UX/UI Development
- **Jessica Meyerson (Educopia/SPN)** Communications/Outreach
- **Kat Thornton (Data Current/WikiDP)** Semantic Architect





Fair use applies to institutions making software available on a cooperative basis to broaden research opportunities, including off-premises access using technology such as Emulation as a Service...

– ARL Code of Best Practices in Fair Use for
Software Preservation

A Very Special Thanks to our Funders...



THE
ANDREW W.
MELLON
FOUNDATION



Alfred P. Sloan
FOUNDATION

A large white circle is centered on a black background. To its left, a smaller grey circle overlaps it. To its right, a dark blue circle overlaps it, containing the EaaS! logo. The text 'Thank you' is centered within the white circle.

Thank you

[https://www.softwarepreservationnetwork.org/
eaasi/](https://www.softwarepreservationnetwork.org/eaasi/)

The logo consists of the text 'EaaS!' in white, with a blue exclamation mark, set against a dark blue circular background. This circle is partially overlapped by the large white circle.

EaaS!