

Solving Visibility and Streaming in The Witcher 3: Wild Hunt with Umbra 3

Jasin Bushnaief, Umbra Software
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UMBRA 3 BY UMBRA SOFTWARE
UMBRA3.COM

CDPROJEKT RED

Agenda

INTRODUCTION

UMBRA 3 OVERVIEW

THE WITCHER 3 REQUIREMENTS

MIDDLEWARE AND THE REDEngine 3

UMBRA 3 IN REDEngine 3



UMBRA SOFTWARE

OCCCLUSION CULLING MIDDLEWARE FOR 3D GAMES

FOUNDED IN 2007

14 EMPLOYEES

BASED IN HELSINKI, FINLAND

SUPPORT OFFICE IN SEATTLE, WA



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Umbra — a force behind many games



With Umbra visibility software, games work consistently and dynamically. Among the games that use the platform is Call of Duty® Ghosts, well known for its demanding technology.

Finland game companies have been taking the world by storm. Behind the games, too, is top know-how and technology that cannot be seen, but which solves the “visibility problems” of the games. Umbra Software’s programs are used in many popular games.

Founded in 2007, Umbra Software specialises in so-called visibility optimisation technology and is practically the only company in the 3D game world to focus on this issue. It might sound complicated, but, in **Thomas Puha’s** view, it’s really quite simple:

— Our software prevents objects that are hidden behind other objects from being rendered in the game world. Essentially it means that the games work better and more consistently, and that they can be enhanced and made more dynamic.

Strong expertise

Although Puha makes it sound easy, it is actually one of the most challenging issues to be resolved in the real-time 3D game world. Visibility optimisation usually demands extensive work by graphic designers, but Umbra’s software does it automatically.

— Our expertise is based on a very high level of technical ability, i.e. programming, and on the ability to solve very complex mathematical problems.

Puha says part of this strong expertise stems from the demoscene of the ‘80s and ‘90s, which saw a subculture of computer hobbyists trying to outdo each other in computer programming using graphics and audio.

— Coding was learnt the hard way, and people taught themselves how to program during the darkest hours of the night, he says.

No shortage of demand

“Level artists are there to fill the world with content. Integrating Umbra saved us not only artist time but the time to create and maintain an efficient visibility culling solution. Umbra’s support provides us with the solutions and features that we need.”

Meet the small Finnish firm helping Call Of Duty, Destiny, Killzone and more look truly next-gen

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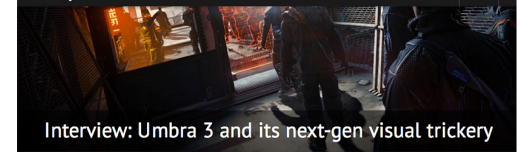
Neil Long at 10:00am November 8 2013



One tiny middleware company from Finland, which currently employs just nine people, will see its graphics optimisation technology stealthily enter millions of players’ homes in the coming months.

“Umbra’s technology is playing an important role in the creation of our next universe, by freeing our artists from the burden of manual markups typically associated with polygon soup.”

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Interview: Umbra 3 and its next-gen visual trickery

By Aaron Lee
November 29th 2013 at 1:00PM

PRINT EMAIL SHARE (75)

Develop speaks to Umbra about its occlusion culling tool and how it’s giving PS4 and Xbox One games that next-gen sheen

Umbra is the game development equivalent of a magic trick. A trick intended to maintain the illusion created by those on-screen polygons and your point of view.

It is this tool that has helped to generate the striking vistas of Killzone: Shadow Fall’s sun-drenched cityscape. Concealed those pesky enemy

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Video games powered by Umbra 3



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CALL OF DUTY
GHOSTS

NEVER SET

Infinity Ward





DESTINY



BUNGE



KILLZONE
SHADOW FALL





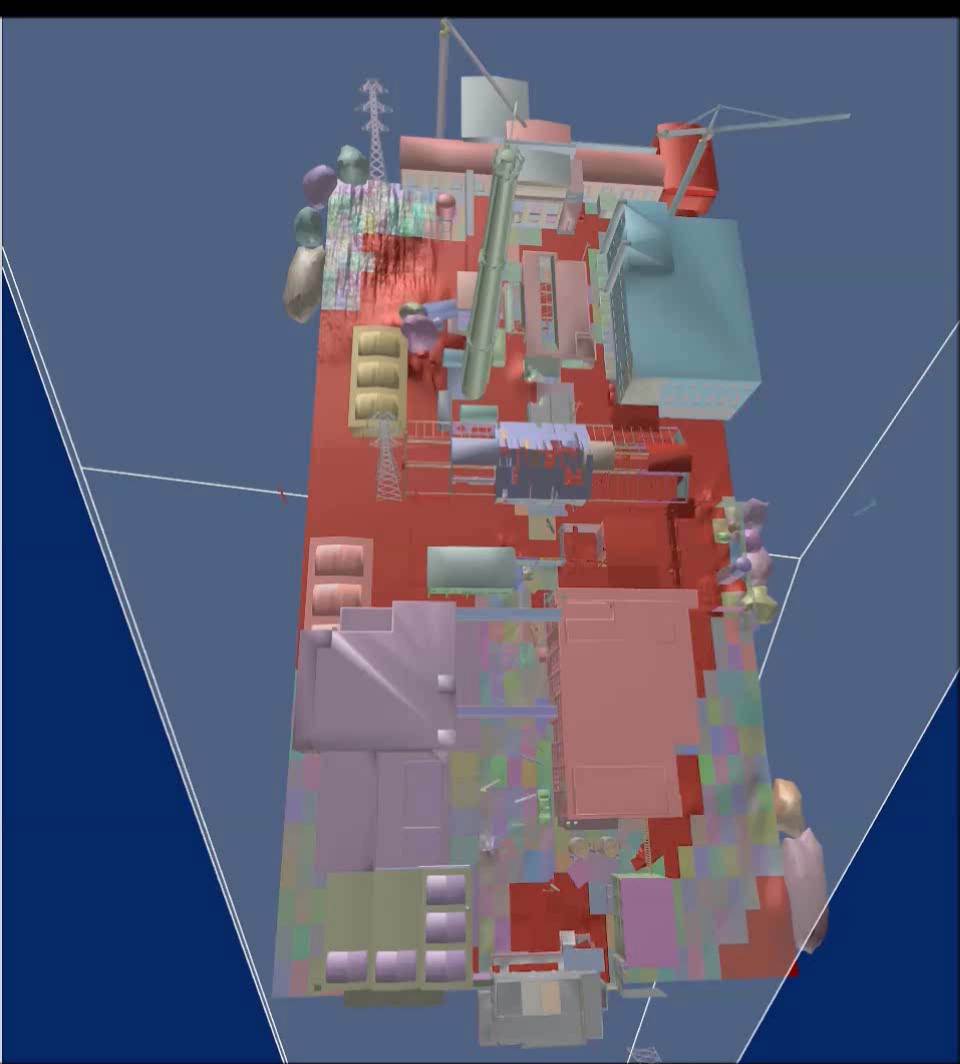
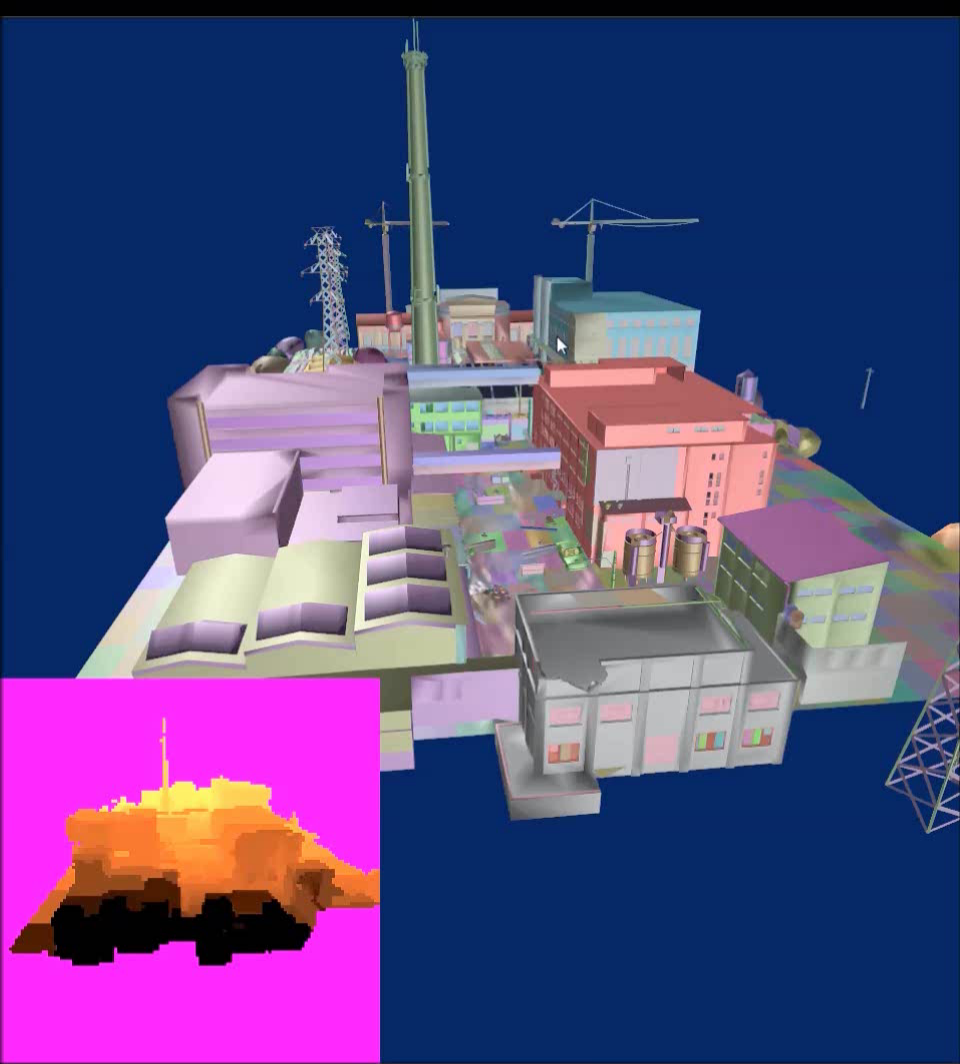
THE
WITCHER 3
WILD HUNT

CD PROJEKT RED

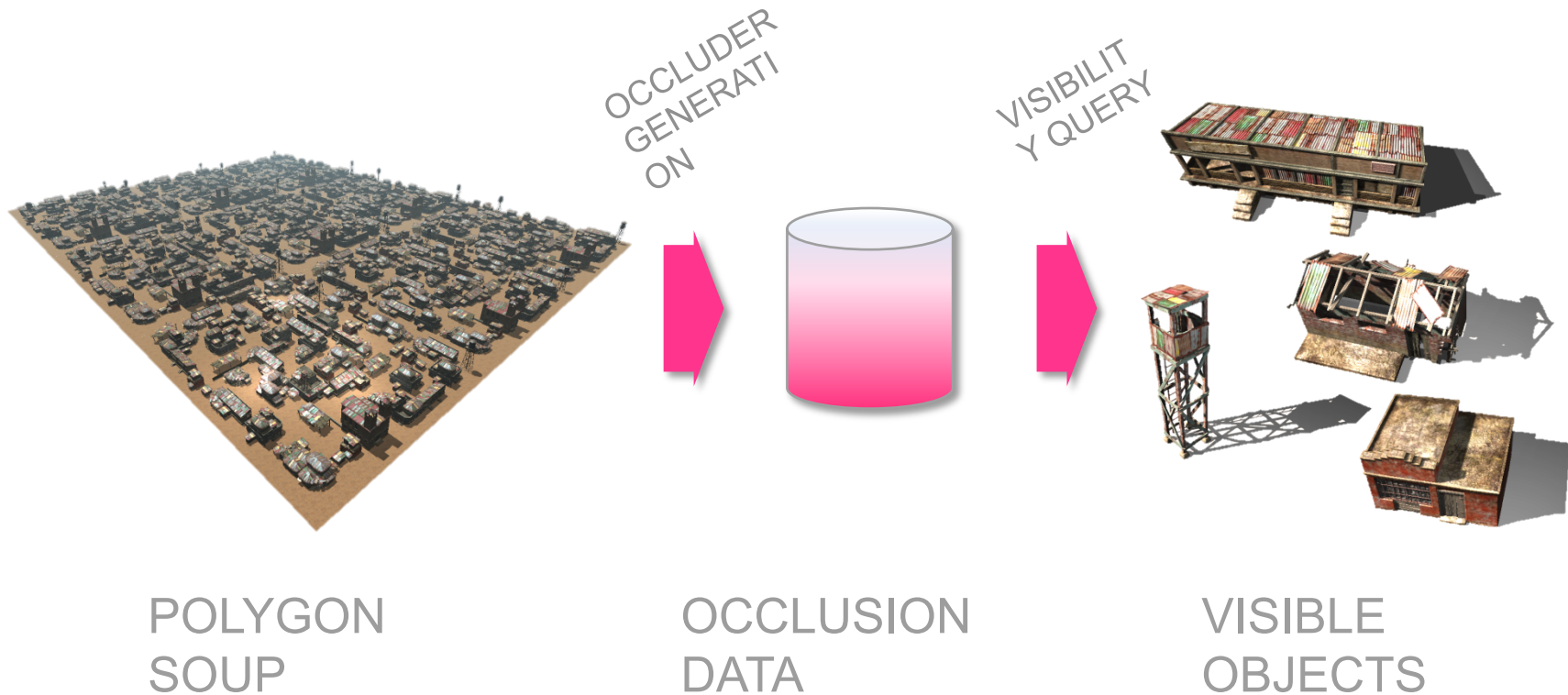
SO WHAT'S

Occlusion Culling

ANYWAY?



UMBRA 3 OVERVIEW



WHY LICENSE?

- + SAVE ENGINEERS' TIME
- + SAVE ARTISTS' TIME
- + IT'S EASY
- + PORTABLE
- + PROVEN
- + SUPPORT



- ENGINEERS DON'T GET TO ROLL THEIR OWN 😞



HOW TO SATISFY

The Witcher 3 Requirements

IN UMBRA 3?

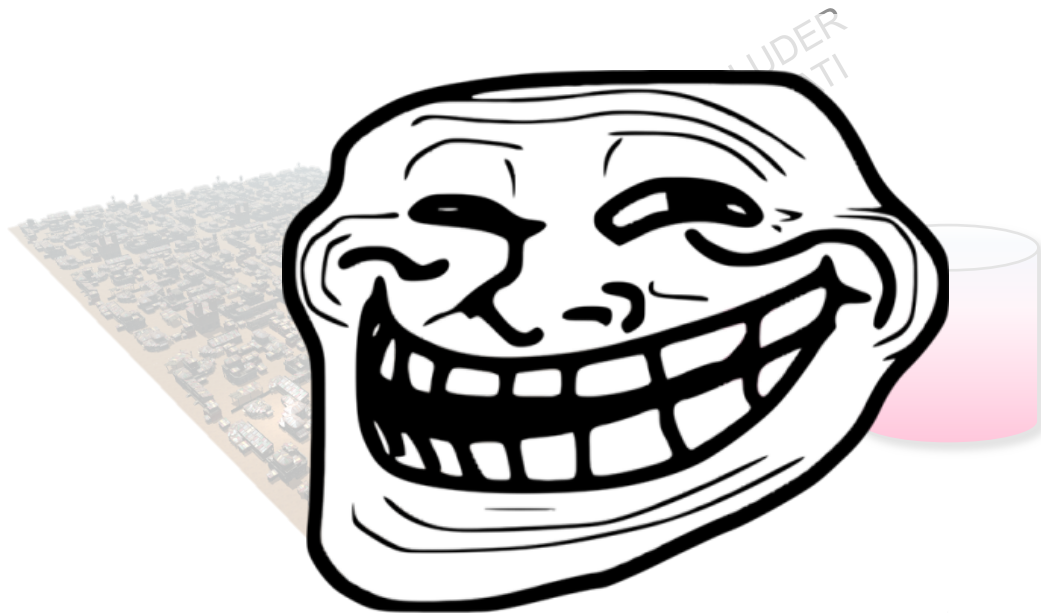
**MAY CONTAIN CONTENT
INAPPROPRIATE FOR CHILDREN**

Visit www.esrb.org
for rating information

THE WITCHER 3 REQUIREMENTS

- LARGE, OPEN WORLD
 - PVS, MANUAL STUFF OUT OF QUESTION
- UMBRA IS AUTOMATIC
- STREAMING
- LODs





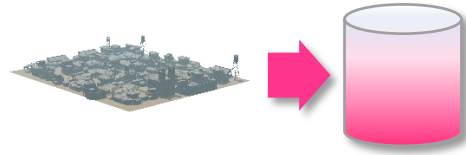
PROBLEM?

POLYGON
SOUP

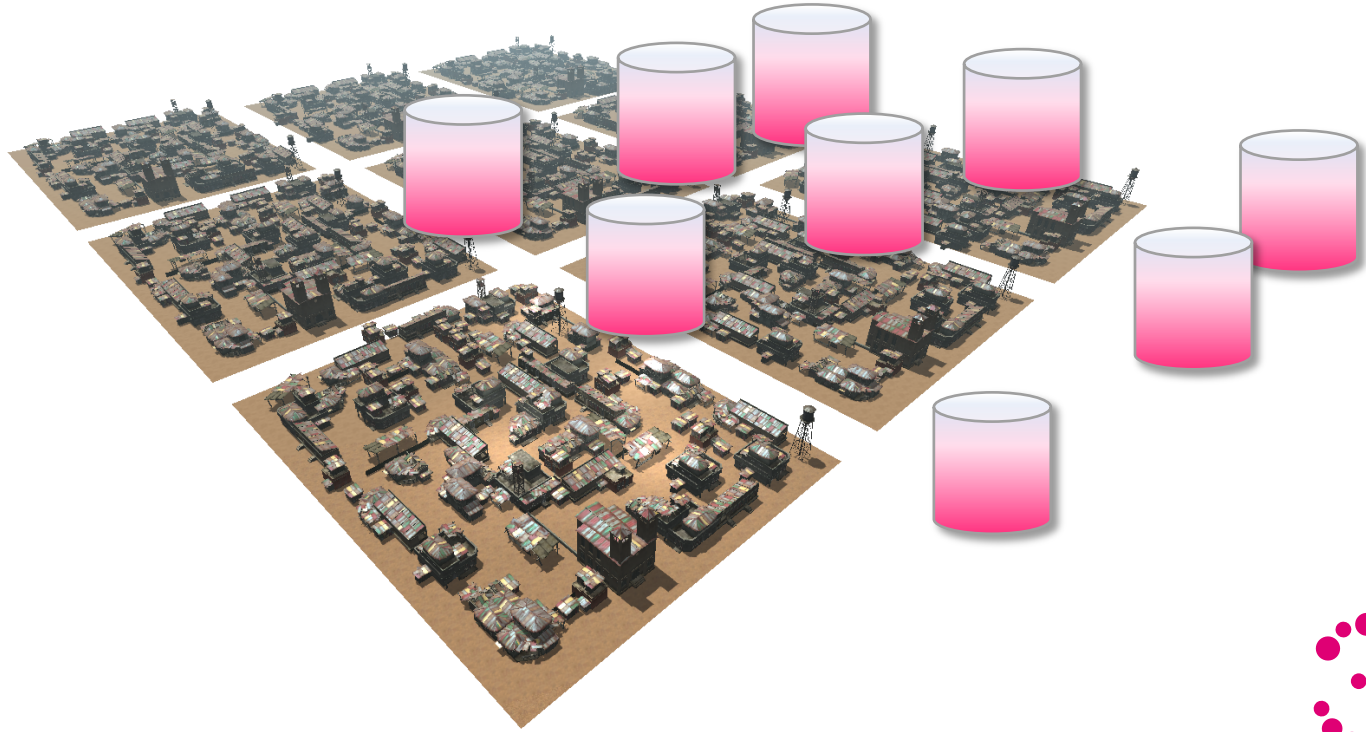
COLLISION
DATA



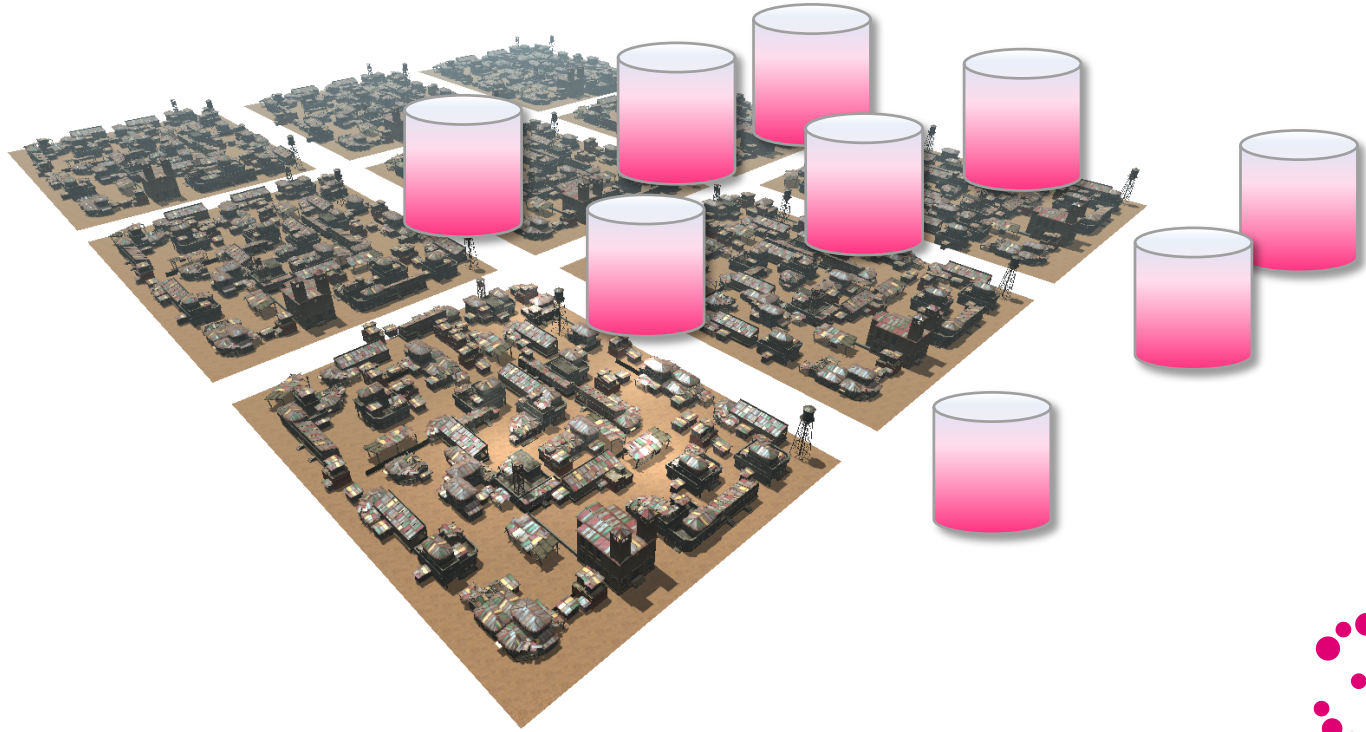
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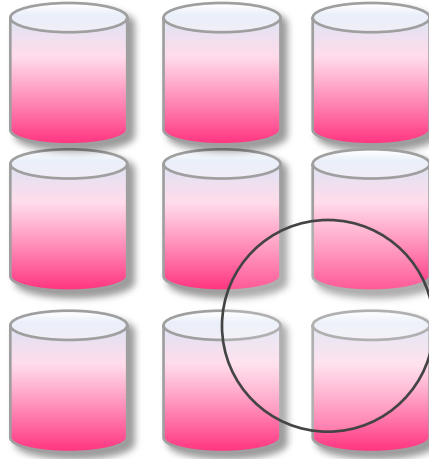
STREAMING IN UMBRA 3



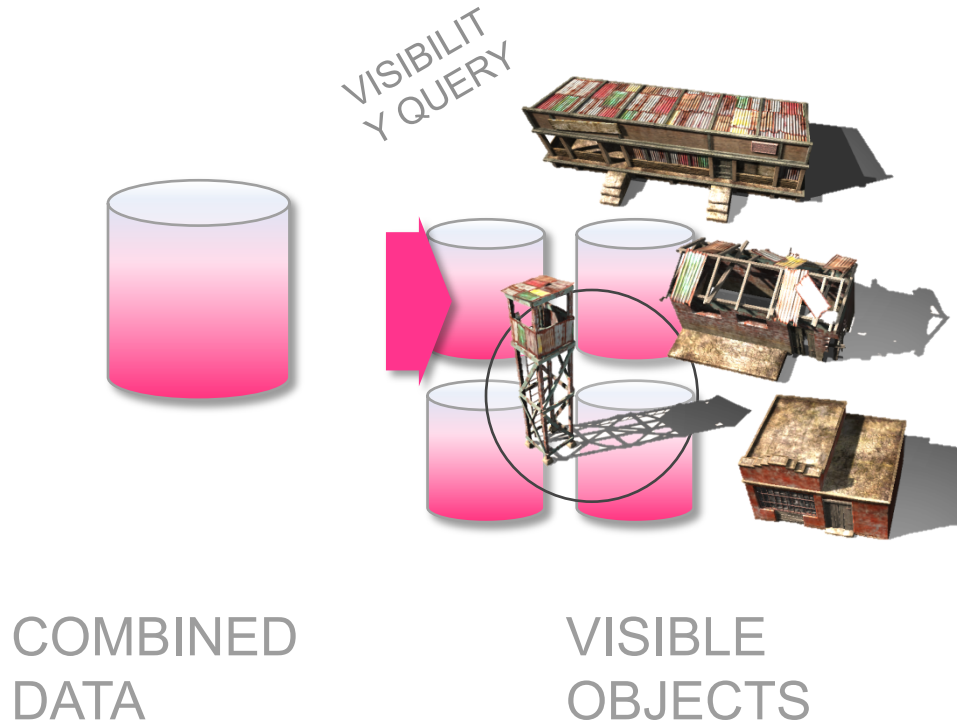
STREAMING IN UMBRA 3



STREAMING IN UMBRA 3



STREAMING IN UMBRA 3



STREAMING CHALLENGES

- INDEPENDENT BLOCKS
- MATCH ON BORDERS
- DO IT QUICKLY!



LODs IN UMBRA 3

- PREVIOUSLY: SCENE CONSISTS OF SINGLE OBJECT INSTANCES
- PROBLEMS:
 - NEED MULTIPLE LOD LEVELS
 - SELF-OCCLUSION BETWEEN LEVELS
 - LOD HIERARCHIES?



LODs SOLVED

DISTANCE RANGE

Z = 0

Z = LIKE, A LOT



LOD 0

(OCCLUDER)

LOD 1

LOD 2

LOD 3



LOD CHALLENGES

- DISTANCE REFERENCE POINT
- OTHER CRITERIA FOR LOD SELECTION
- SMARTER LOD OCCLUDERS



ABOUT CD PROJEKT RED

- Located in Warsaw and Cracow, Poland
- Established in 2002
- Focused on RPGs

ABOUT CD PROJEKT RED

- **The Witcher (2007)**
 - PC, heavily modified Aurora Engine
- **The Witcher 2: Assassins of Kings (2011)**
 - PC, heavily modified Aurora Engine
- **The Witcher 2: Assassins of Kings Enhanced Edition (2012)**
 - PC/X360, REDengine 2
 - metacritics score: 88

ABOUT CD PROJEKT RED

- **The Witcher 3: Wild Hunt**

- REDengine 3
- Releasing in February 2015
- PC/XBOX / PS4

- **Cyberpunk 2077**

- REDengine 3
- Release date TBD



THE WITCHER 3: WILD HUNT

35x bigger than The Witcher 2

- open world
- complex streaming
- a lot of tools refactoring
- different approaches

Engine team:

- 16 people



AGENDA

- **Why middleware?**
 - Things we consider
 - Umbra 3 as middleware for REDengine 3
- **Integration process**
 - Editor features
 - Cooker / data generation
 - Game features
- **Summary**

WHY MIDDLEWARE?

• Pros

- Too much time to provide own solutions
- Documentation
- Customer support
- Often access to source code
- Specific solutions for specific game

• Cons

- Evaluation time
- Pipeline modifications
- Code integrations
- Code not written by us

WHY MIDDLEWARE?

- **“Business” aspects**

- Documentation – quality
- Customer support
- Changes to our pipeline
- Source / libs

- **Technical aspects**

- Changes to our pipeline
- Memory management
- Multithreading
- Amount of data to provide
- How it “fits” the engine

WHY MIDDLEWARE?

- **Middlewares that we use in the game**

- Umbra 3
- PhysX
- APEX
- SpeedTree
- Wwise
- Scaleform

UMBRA 3 AS A MIDDLEWARE FOR REDengine 3

- **Documentation**

- Description of the classes, methods and concepts behind solutions
- basic tutorials

- **Access to source code /**

libraries

- Both

- **Customer support**

- Great

UMBRA 3 AS A MIDDLEWARE FOR REDengine 3

- **Memory management**

- Ability to plug in your own allocator

- **Multithreading**

- Multithreaded building and queries

- **Amount of data to provide**

- Triangle soup
- No additional data created by artists

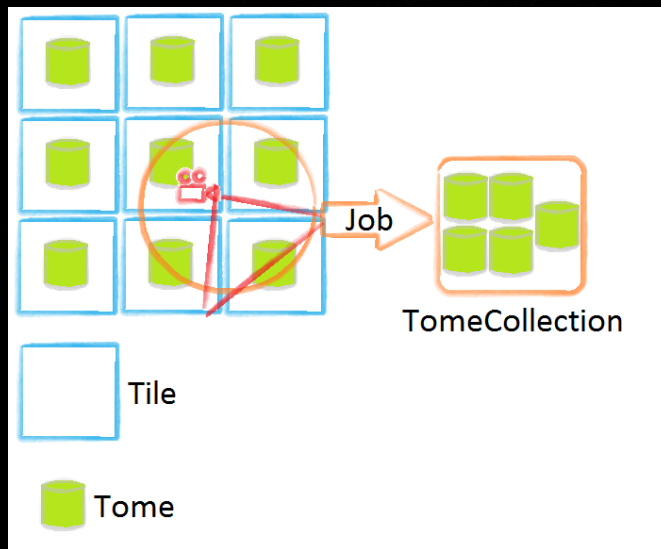
- **Additional work**

- Coming up with ID scheme
- Including occlusion culling in the rendering part
- Tools for building occlusion data

UMBRA 3 IN REDengine 3

Editor features

OCCLUSION DATA STREAMING



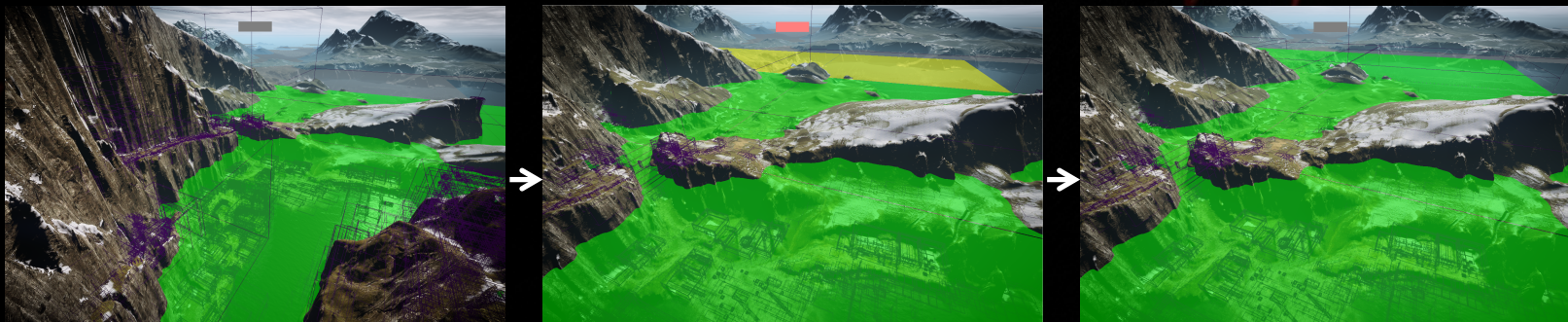
OCCLUSION DATA STREAMING

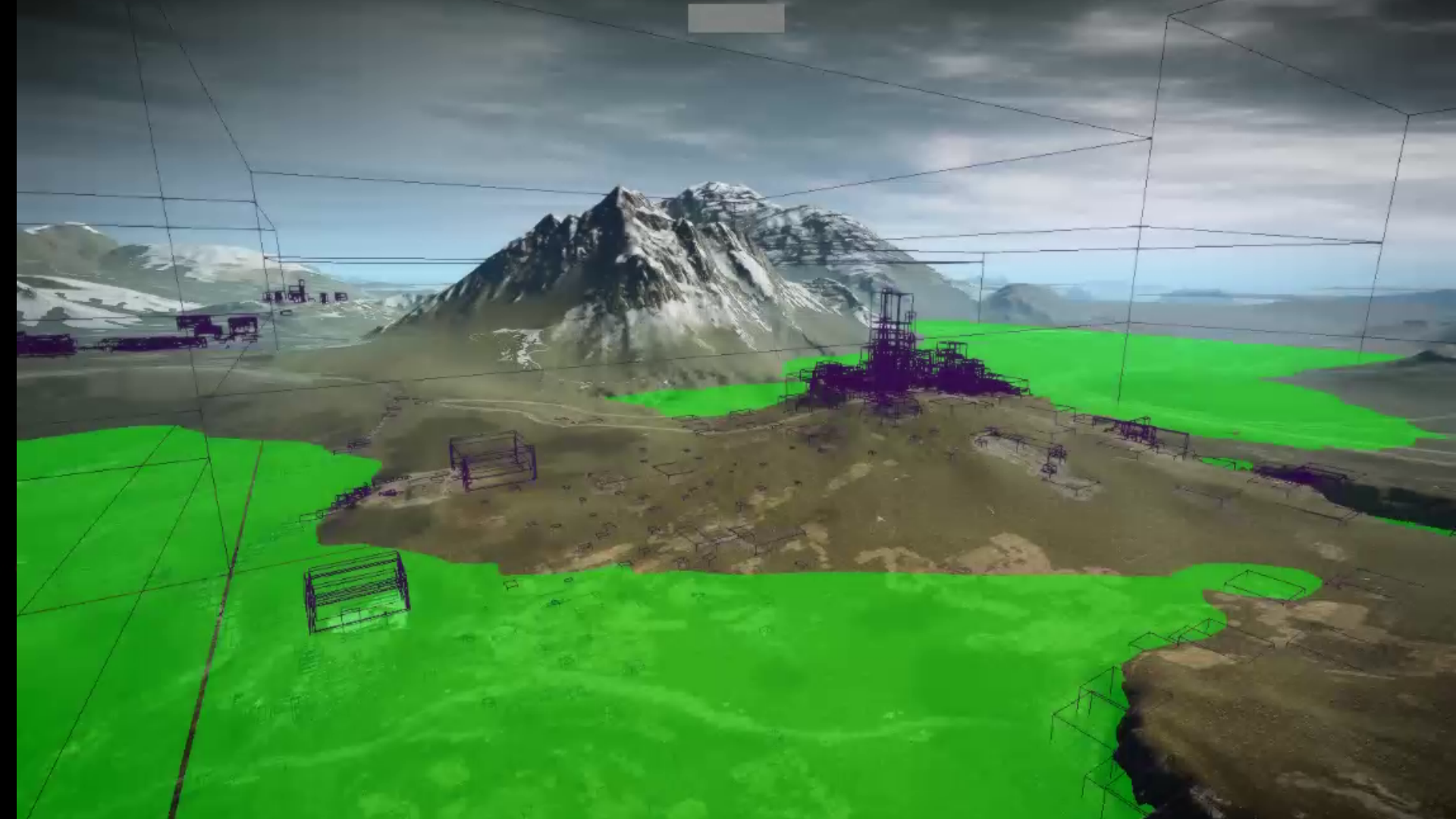
1. From certain camera position required set of Tiles is determined
2. If the newly determined set differs from the currently used one, asynchronous computation starts
3. Precooked buffers are streamed in (only for Tiles, that had no data streamed in yet)
4. Tome objects are created (only for Tiles that haven't had this object created yet)
5. Once all the Tomes exist, the TomeCollection object is created from them
6. Newly created TomeCollection is sent to renderer to replace the currently used one
7. Tiles that are no longer necessary destroy their Tome object and unstream the precooked data buffers. Previous TomeCollection object is destroyed.

OCCLUSION DATA STREAMING



OCCLUSION DATA STREAMING



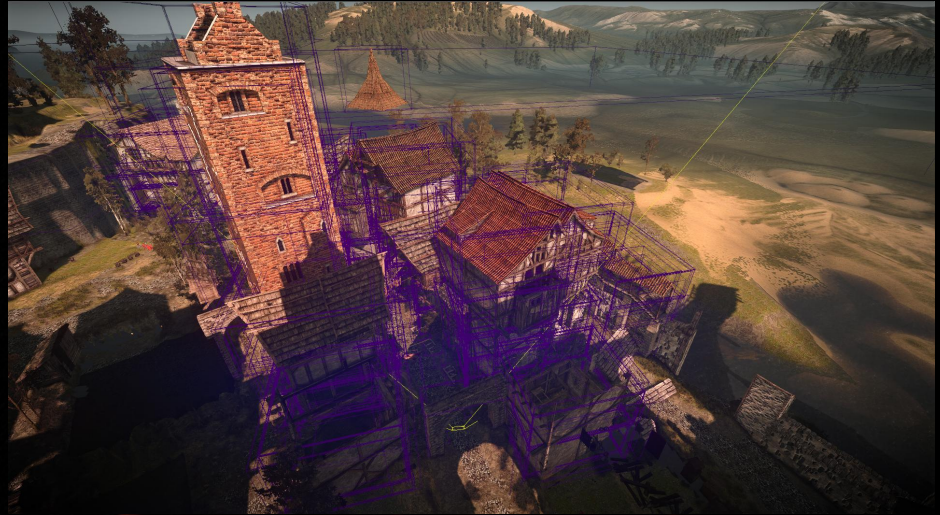


- **Quite a few in-engine tools**
 - Detachable camera
 - Streaming visualizations
 - Memory statistics
 - Geometry statistics
 - All visualizations that Umbra library gives us

SAMPLE SCENE

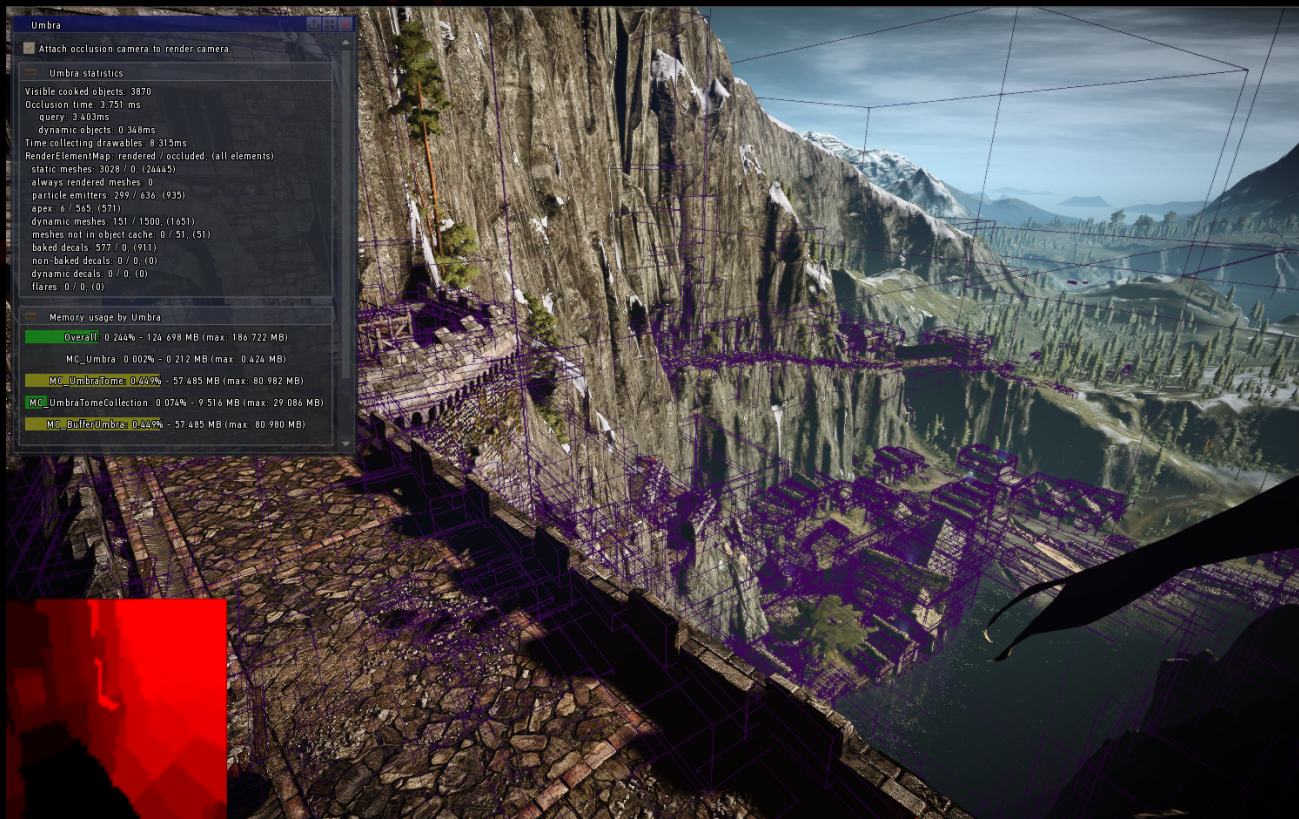
CDPROJEKT

- **43** Tomes loaded
- **61 MB** of Tome data loaded
- Additional **15 MB** of inter-Tome data generated on the fly
- Over **62000** static mesh chunks on scene
- Less than **500** visible (**~0.76%**)
- Query time: **~1.8 ms**
- Dynamic objects occlusion:
 - Particles
 - Skinned meshes
 - Simulated meshes
 - Decals

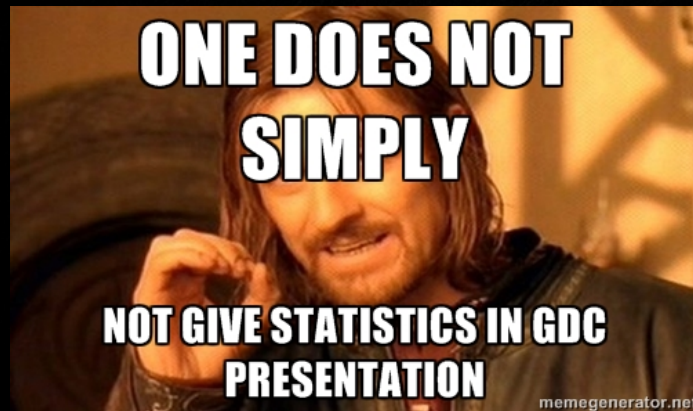


DEBUG OVERLAY / STATISTICS

CDPROJEKT



STATISTICS



- **Skellige**

- Area size: **8km x 8km**
- Amount of geometry: **45000-50000** chunks loaded
- Average amount of visible geometry: **~1-5%**

- **City of Novigrad**

- Area size: **8.5km x 8.5km**
- Amount of geometry: **over 100k** chunks loaded
- Average amount of visible geometry: **~2-5%**

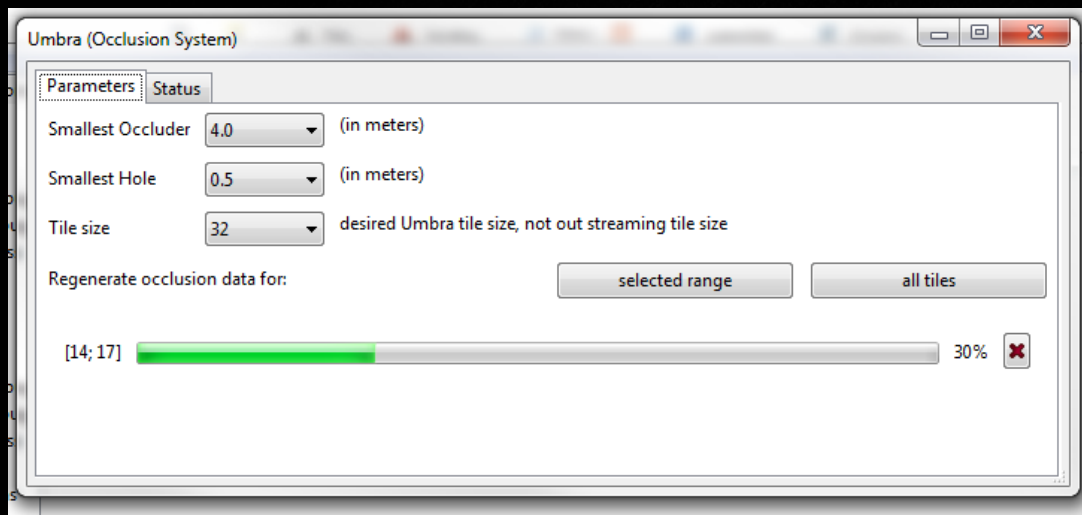
- **Size of Umbra data (cooked data + object IDs)**
 - Skellige: ~300 MB
 - Novigrad: ~250 MB
- **Size of data loaded during runtime**
 - Skellige: 40-80 MB
 - Novigrad: 45-80 MB

COOKER / DATA GENERATION

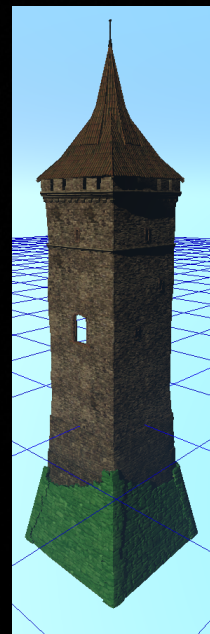
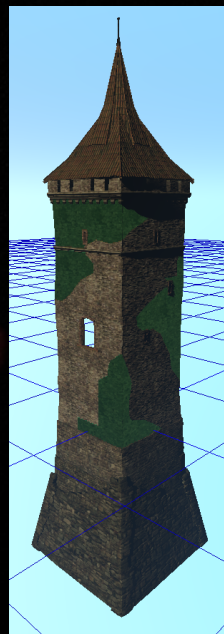
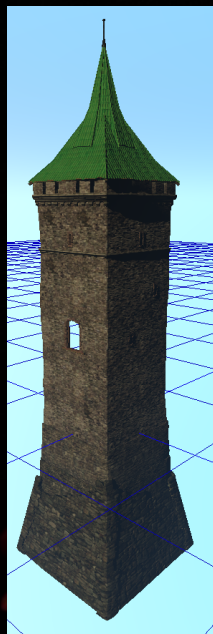
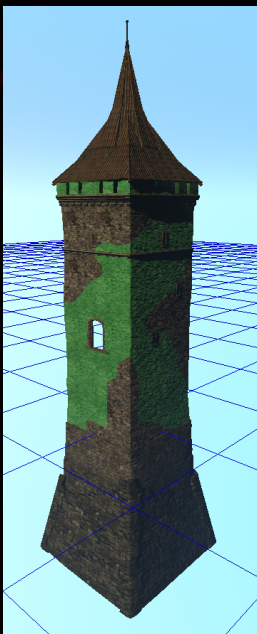
- Offline process
- Data built more than once per day
- Dedicated machines (server farm)

```
TObjectIdType objectId;
if ( chunk->GetUmbraObjectId( objectId ) )
{
    E:\Perforce\Main.Core\dev\src\...\bin\x64\wcc.exe
    [2014.03.04 17:55:31][Info][UmbraInfo] Memory budget for tile computation is 307
    2 MB
    [17:55:31 INFO: Umbra 3 Optimizer version 3.3.5 (build: f57e76c1b9350cf98632cd
    589ed6a79ebfcafe6)
    [2014.03.04 17:55:31][Info][UmbraInfo] Umbra 3 Optimizer version 3.3.5 (build:
    f57e76c1b9350cf98632cd589ed6a79ebfcafe6)
    [17:55:32] INFO: T: 8 O: 2 H: 0.25 B: 20
    [2014.03.04 17:55:32][Info][UmbraInfo] T: 8 O: 2 H: 0.25 B: 20
    [17:56:09] INFO: Tile grid 128x128x64 (at 256,896,-32) created for scene: 6031 t
    iles (0 empties not included) in 36.695 seconds
    [2014.03.04 17:56:09][Info][UmbraInfo] Tile grid 128x128x64 (at 256,896,-32) cre
    ated for scene: 6031 tiles (0 empties not included) in 36.695 seconds
    [17:56:09] INFO: Using 3 threads to compute 6031 tiles, cache -1 MB
    [2014.03.04 17:56:09][Info][UmbraInfo] Using 3 threads to compute 6031 tiles, ca
    che -1 MB
    [2014.03.04 17:56:13][Info][UmbraInfo] Tile [26; 31] progress: 1
    [2014.03.04 17:56:16][Info][UmbraInfo] Tile [26; 31] progress: 2
    [2014.03.04 17:56:31][Info][UmbraInfo] Tile [26; 31] progress: 3
    [2014.03.04 17:56:40][Info][UmbraInfo] Tile [26; 31] progress: 4
    [2014.03.04 17:56:49][Info][UmbraInfo] Tile [26; 31] progress: 5
    [2014.03.04 17:56:55][Info][UmbraInfo] Tile [26; 31] progress: 6
    [2014.03.04 17:57:01][Info][UmbraInfo] Tile [26; 31] progress: 7
    [2014.03.04 17:57:10][Info][UmbraInfo] Tile [26; 31] progress: 8
    [2014.03.04 17:57:25][Info][UmbraInfo] Tile [26; 31] progress: 9
    [2014.03.04 17:57:31][Info][UmbraInfo] Tile [26; 31] progress: 10
}
}
TObjectIdType objectId;
if ( chunk->GetUmbraObjectId( objectId ) )
{
    chunk->SetUmbraObjectId( objectId );
}
}
```

- Ability to build data in the editor



Chunks – parts of the same mesh



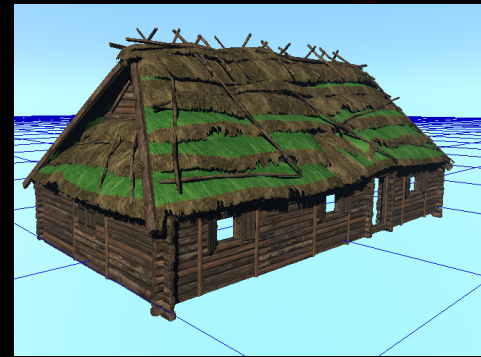
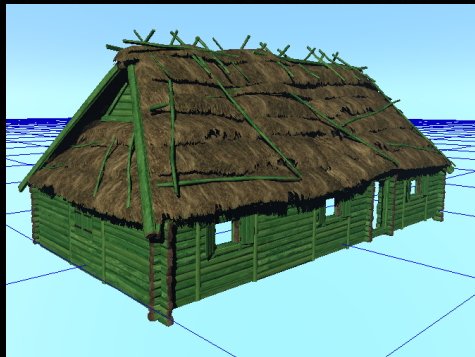
- **LOD levels**

- Each has drawing distance
- Set up by artists

Data Generation:

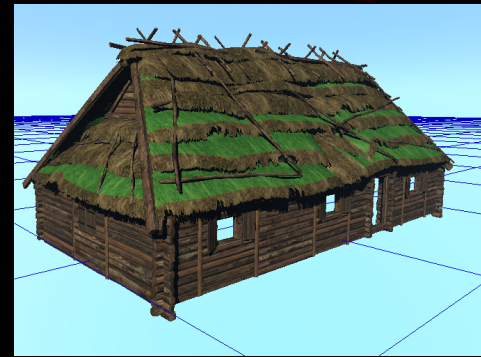
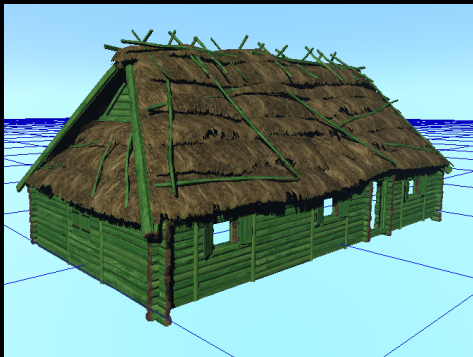
- **Gather mesh**

- Gather LOD level
 - Gather chunks
 - Assign LOD distances
 - Assign unique ID



Retrieving data during runtime:

- Query Umбра for IDs
 - Find chunk
 - Push chunk for drawing
 - Only visible ones
 - Proper LOD level



GAME FEATURES



GDC 2014

Solving Visibility and Streaming in the The Witcher 3: Wild Hunt with Umbra 3

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BATMAN

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