Pollution bug <- NAILED

Discussion in 'Civ1 - General Discussions' started by darkpanda, Oct 14, 2014.

darkpanda
Dark Prince

Joined: Oct 28, 2007
Messages: 600

Although I never put it at the center of my focus, stories about the "pollution bug" have been kept roaming at the back of my mind ever since I became active on those forums, and read people mentioning it here and there.

Being more or less done with the City Process routine (I'm not done yet, in fact, but a bi tired), I thought it would be more fun to investigate this so-called pollution bug one way or another.

So, first thing, I looked up the forums for related threads, and here is what I found:

- Pollution bug - Jan 2003
- Pollution - Jan 2003
- Did anyone try to remove the pollution? - Jun 2008
- Pollution "Bug" - Nov 2007
- Weird pollution bug? - Dec 2011

Some of the above links contain detailed game logic, extracted from "Rome on 640K a Day" regarding pollution, namely how known Techs influence pollution, how a city's power source influence chimneys, how population influence pollution, as well as shields production (or did it?).

Anyhow, I had already identified a very small routine in CIV.EXE, that I bluntly called "AddPollution(x, y)". It seems this routine is used anytime pollution should be added to the map (nuke, city process, ...).

Back-tracking the call from the City Process routine, I could finally dig out what I believe to be the cause of this famous "bug".

Here the raw piece of assembly, for the die-hards out there:

Spoiler : Hide

Code:

```
seg007:633F
seg007:633F     seg007_633F:                            ; CODE XREF: cityProcess_cityID_mode_?1_?2_?3+62F7↑j
seg007:633F 10C                 mov     ax, cityShieldsProd_dseg_705C
seg007:6342 10C                 cwd                     ; AX -> DX:AX (with sign)
seg007:6343 10C                 mov     cx, dseg_6C18_CityPowerType
seg007:6347 10C                 idiv    cx              ; Signed Divide
seg007:6349 10C                 sub     ax, 14h         ; Integer Subtraction
seg007:634C 10C                 mov     [bp+var_pollutionProd], ax
seg007:6350 10C                 mov     ax, 1Ch
seg007:6353 10C                 imul    [bp+arg_cityID] ; Signed Multiply
seg007:6356 10C                 mov     bx, ax
seg007:6358 10C                 mov     al, CityData.ActualSize[bx]
seg007:635C 10C                 cbw                     ; AL -> AX (with sign)
seg007:635D 10C                 imul    pollutionFactor_dseg_C7A2 ; Signed Multiply
seg007:6361 10C                 cwd                     ; AX -> DX:AX (with sign)
seg007:6362 10C                 xor     ax, dx          ; Logical Exclusive OR
seg007:6364 10C                 sub     ax, dx          ; Integer Subtraction
seg007:6366 10C                 mov     cx, 2
seg007:6369 10C                 sar     ax, cl          ; Shift Arithmetic Right
seg007:636B 10C                 xor     ax, dx          ; Logical Exclusive OR
seg007:636D 10C                 sub     ax, dx          ; Integer Subtraction
seg007:636F 10C                 add     [bp+var_pollutionProd], ax ; Add
seg007:6373 10C                 mov     bx, cityOwner
seg007:6377 10C                 shl     bx, 1           ; Shift Logical Left
seg007:6379 10C                 mov     ax, perCivTechCount[bx]
seg007:637D 10C                 imul    difficultyLevel ; Signed Multiply
seg007:6381 10C                 cwd                     ; AX -> DX:AX (with sign)
seg007:6382 10C                 sub     ax, dx          ; Integer Subtraction
seg007:6384 10C                 sar     ax, 1           ; Shift Arithmetic Right
seg007:6386 10C                 sub     ax, 100h        ; Integer Subtraction
seg007:6389 10C                 neg     ax              ; Two's Complement Negation
```

This code block is one of the first condition to be assessed when checking whether pollution should be spawned.

Re-writing the condition in a single formula, it gives this:
IF (2 * CityPollution > Random(256 - CityOwnerTechCount * difficultyLevel / 2)) THEN AddPollution

In the above, **CityPollution** is computed as explained in other threads:
CityPollution = CityShields / CityPowerType - 20 + CitySize * PollutionFactor

CityPowerType depends on the power infrastructure in the city (default/power plant = 1, hydro/nuke plant = 2, recycling center = 3)
PollutionFactor depends on the "polluting" techs known by the player (INDUSTRIALIZATION=1, AUTOMOBILE=2, MASS PRODUCTION=3 and PLASTICS=4), and whether the city has a MASS TRANSIT (= 0).

So we can see that multiple combination are possible, but the key to this bug lies in the RANDOM() call: what if **CityOwnerTechCount * difficultyLevel / 2** is more than **256**?

Then the RANDOM() call has a **negative** argument, for which it will always return **zero**.

In other words, as soon as one gets **(256*2/difficultyLevel)** Techs, pollution starts to get triggered at every turn.

Let's make a list:

- **Chieftain** = 0: (256*2/0) = +infinity -> pollution bug **never triggered**
- **Warlord** = 1: (256*2/1) = 512 -> pollution bug triggered after **Future Tech. 444** (512 - 68 non-future techs)
- **Prince** = 2: (256*2/2) = 256 -> pollution bug triggered after **Future Tech. 188** (256 - 68 non-future techs)
- **King** = 3: (256*2/3) = 170 -> pollution bug triggered after **Future Tech. 102** (170 - 68 non-future techs)
- **Emperor** = 4: (256*2/4) = 128 -> pollution bug triggered after **Future Tech. 60** (128 - 68 non-future techs)

The theoretical numbers seem to *more or less* match what people have reported in the various threads above, although some other unknown conditions may add variations.

Anyhow, for me, the riddle is solved.

The riddle in the riddle that isn't solved, though, is: was this done on purpose? I guess we'll never know... 😉

Now, how would you guys out there suggest to *patch* it?

JCivED - a toolbox for Sid Meier's Civilization (MS-DOS)

darkpanda, Oct 14, 2014 #1

I can't speculate on what might be wrong, but this formula suggests that if a Mass Transit and Recycling center are both present, a city of any size can produce up to 60 shields before **2*CityPollution > 0**. I guess if we're dealing with a **≥** or the engine is allowed to generate a signed random value (you'd know better than me) then I

Tristan_C
Chieftain

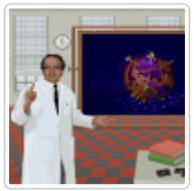
Joined: Aug 16, 2006
Messages: 1,309

think the bug would occuring without fail through that formula.

This is a magnificent find by the way. One patch proposal would be to throw a line returning the lesser of **CityOwnerTechCount** and **68** and use that value in place of the direct TechCount— freezing the effect of future techs.

But if the formula is exactly right, then I think the in-game, unmodded work-around is more than sufficient: ensure that cities have the Transit and Recycle and aren't breaking the ceiling with shields. If you can get to future tech 60 than surely you can afford a recycling center...

Tristan_C, Oct 14, 2014 #2



SWY
Chieftain

Joined: Oct 3, 2014
Messages: 329
Gender: Male
Location: The Netherlands

Isn't it possible (and realistic) to just not take future technologies into account when calculating total advances? I would hope that the future brings us cleaner and greener technologies.

CivOne - A Civilization remake in C#: Forum Thread - Website - GitHub

SWY, Oct 15, 2014 #3

darkpanda
Dark Prince

Joined: Oct 28, 2007
Messages: 600

> Tristan_C said: ↑
>
> *...or the engine is allowed to generate a signed random value...*

I originally thought that the CIV.EXE's Random routine would simply return 0 if the argument is negative, but my Java port of this routine will actually return negative values when the argument is negative...

If it returns negative values, then it makes the bug all the more prominent since even when benefiting from 20 free chimneys, 2*CityPollution might be higher than the Ranom result!

Needs to be checked in-game...

JCivED - a toolbox for Sid Meier's Civilization (MS-DOS)

darkpanda, Oct 15, 2014 #4

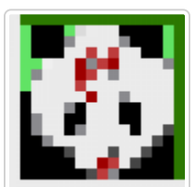
Tristan_C
Chieftain

Joined: Aug 16, 2006
Messages: 1,309

> darkpanda said: ↑
>
> *I originally thought that the CIV.EXE's Random routine would simply return 0 if the argument is negative, but my Java port of this routine will actually return negative values when the argument is negative...*
>
> *If it returns negative values, then it makes the bug all the more prominent since even when benefiting from 20 free chimneys, 2*CityPollution might be higher than the Ranom result!*
>
> *Needs to be checked in-game...*

So as things stand, I suppose this would be a prime suspect on why the bug is occurring. Speaking from some experience (future tech 64 on my part) this bug is very prominent indeed, but one big issue is lack of documentation. Few games are played out to this point and of those next to none have been walked through carefully for testing.

Tristan_C, Oct 15, 2014 #5



darkpanda
Dark Prince

Joined: Oct 28, 2007
Messages: 600

> SWY said: ↑
>
> *Isn't it possible (and realistic) to just not take future technologies into account when calculating total advances? I would hope that the future brings us cleaner and greener technologies.*

Yes this is what Tristan_C is proposing by replacing "CityOwnerTechCount" with "MIN(CityOwnerTechCount, 68)"... But to implement this in assembly is difficult, mainly because of the lack of room to put the patch bytes.

JCivED - a toolbox for Sid Meier's Civilization (MS-DOS)

darkpanda, Oct 15, 2014 #6

Svetkavitsa

> darkpanda said: ↑
>
> *Now, how would you guys out there suggest to patch it?*

The simplest patch would be to either replace the difficulty with 0 (always chieftan), or to change one of the modifiers to push the bug back further (divide by 4 or 6), but those both reduce all pollution everywhere, affecting game difficulty.
IF (2 * CityPollution > Random(256)) THEN AddPollution

Chieftain

Joined: Sep 12, 2010
Messages: 46
Location: Utah, USA

or
IF (2 * CityPollution > Random(256 - CityOwnerTechCount * difficultyLevel / 4)) THEN AddPollution

A cool solution (doubtful to be able to be done in place) would be to take the absolute value before calling the rand(), so that future techs eventually reduced pollution. There would still be a period where pollution would be rampant...
IF (2 * CityPollution > Random(abs(256 - CityOwnerTechCount * difficultyLevel / 2))) THEN AddPollution

Something that might be possible and more in line with what the developers wanted, would be using PollutionFactor*multiplier instead of CityOwnerTechCount, where multiplier would probably be 16 or 17 (researching plastics gives you the same value as having all techs researched). Now, I'm familiar with assembly (from a CS class almost 10 years ago), but far from fluent, so I'm not entirely sure if PollutionFactor is available for use at that point in the calculations. It would also be nice if mass transits didn't factor in (otherwise having one would give you Chieftan difficulty pollution levels), but I think it would be awesome if it could be implemented this way.
IF (2 * CityPollution > Random(256 - PollutionFactor * difficultyLevel * 8)) THEN AddPollution

Svetkavitsa, Dec 15, 2014 #7

Folket
Chieftain

Joined: Jan 7, 2010
Messages: 3,739
Location: Sweden

Would you not be able to add a procedure at the end of the file and rewrite the function there? Then just call that.

"It's good to know that powerful spirits inhabiting enormous stone constructions are still vulnerable to hypothermia" /brxbrx

Folket, Aug 24, 2015 #8

darkpanda
Dark Prince

Joined: Oct 28, 2007

I think I would be able to do something like that, but it is definitely not simple - and I didn't try it yet.

JCivED - a toolbox for Sid Meier's Civilization (MS-DOS)

darkpanda, Aug 24, 2015 #9

Messages: 600

MiGaNuTs
Chieftain

Joined: Jan 3, 2011
Messages: 11

(up ☺)

MiGaNuTs, Jun 13, 2016 #10

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