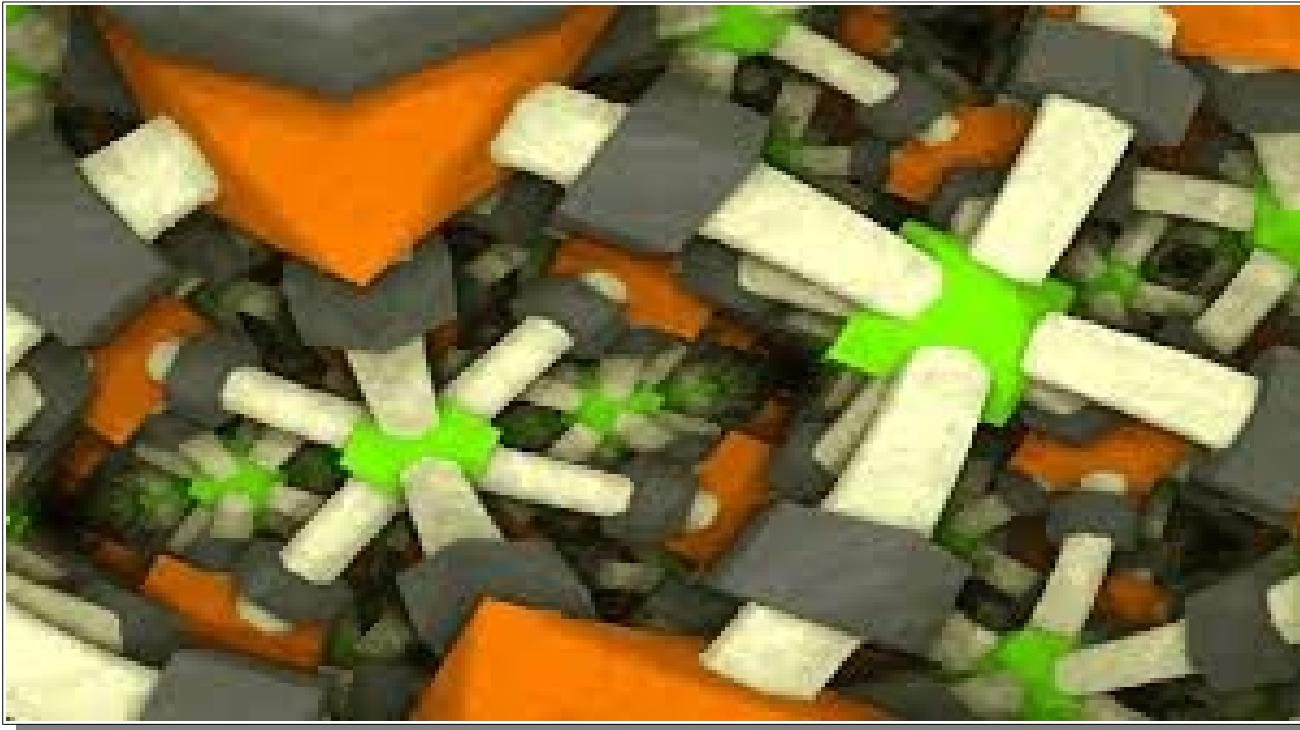


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# 256-byte demoscene: extremly strong competition

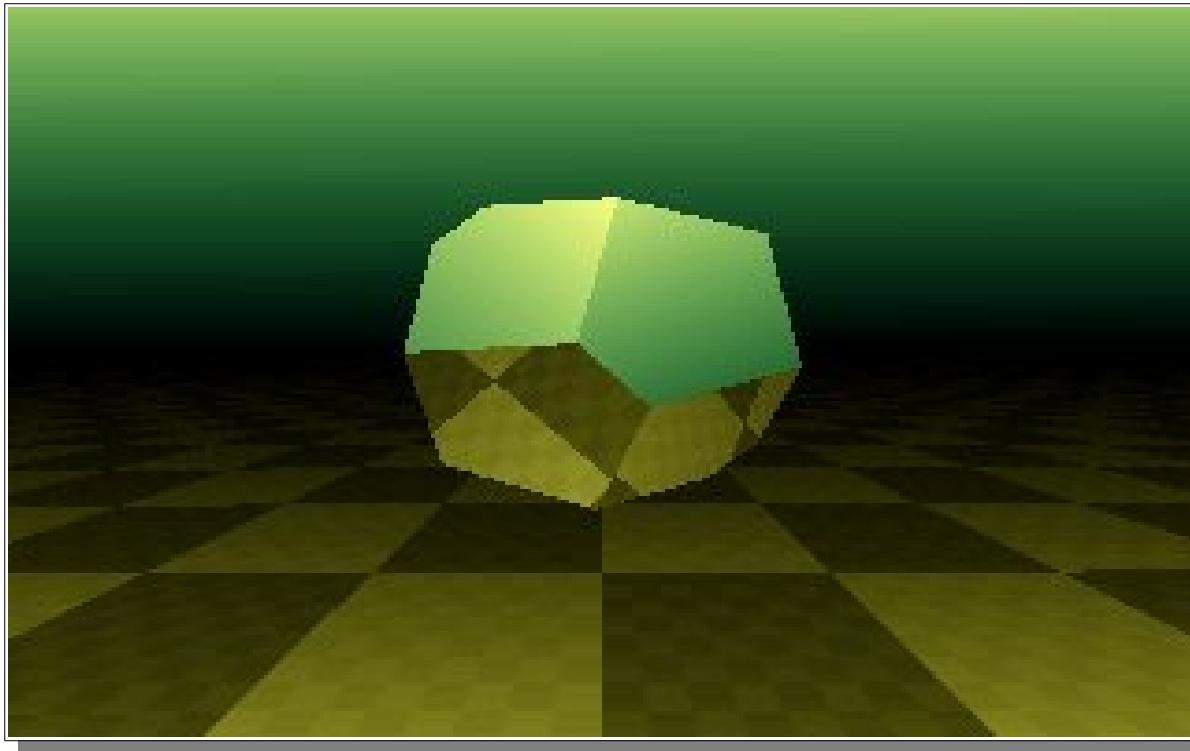


256-byte demoscene: extremly strong competition



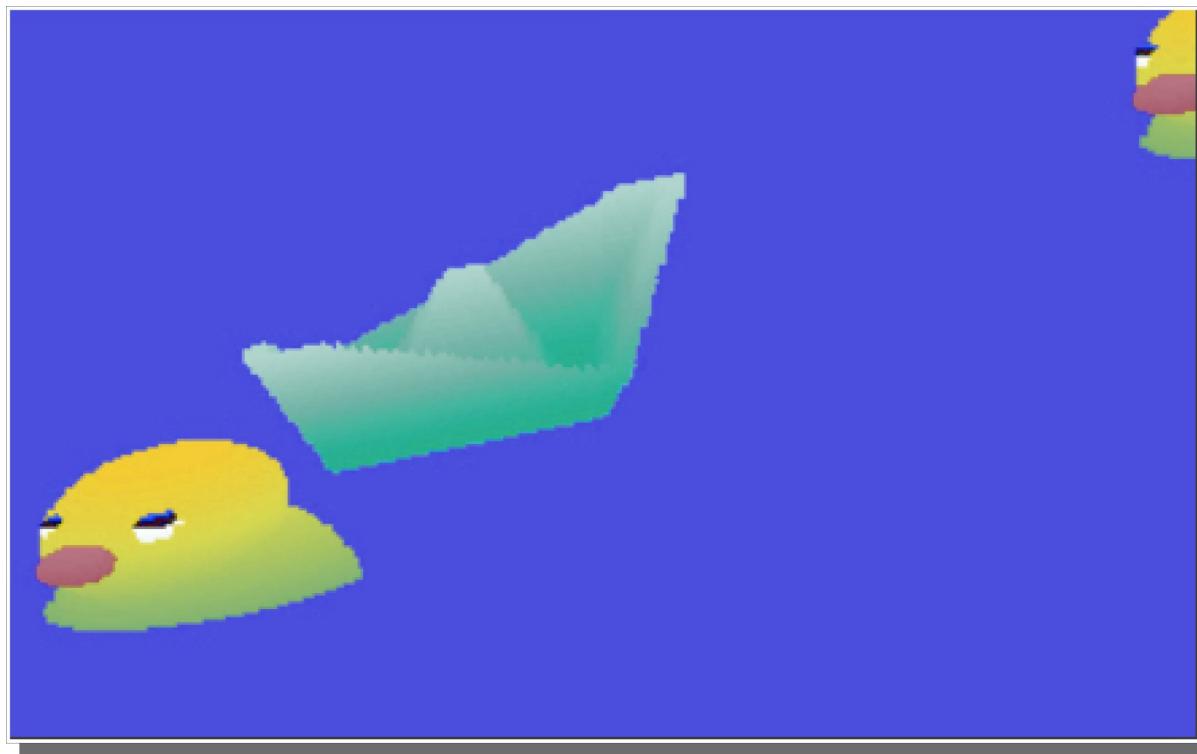
*Řrřola: Puls*

256-byte demoscene: extremly strong competition



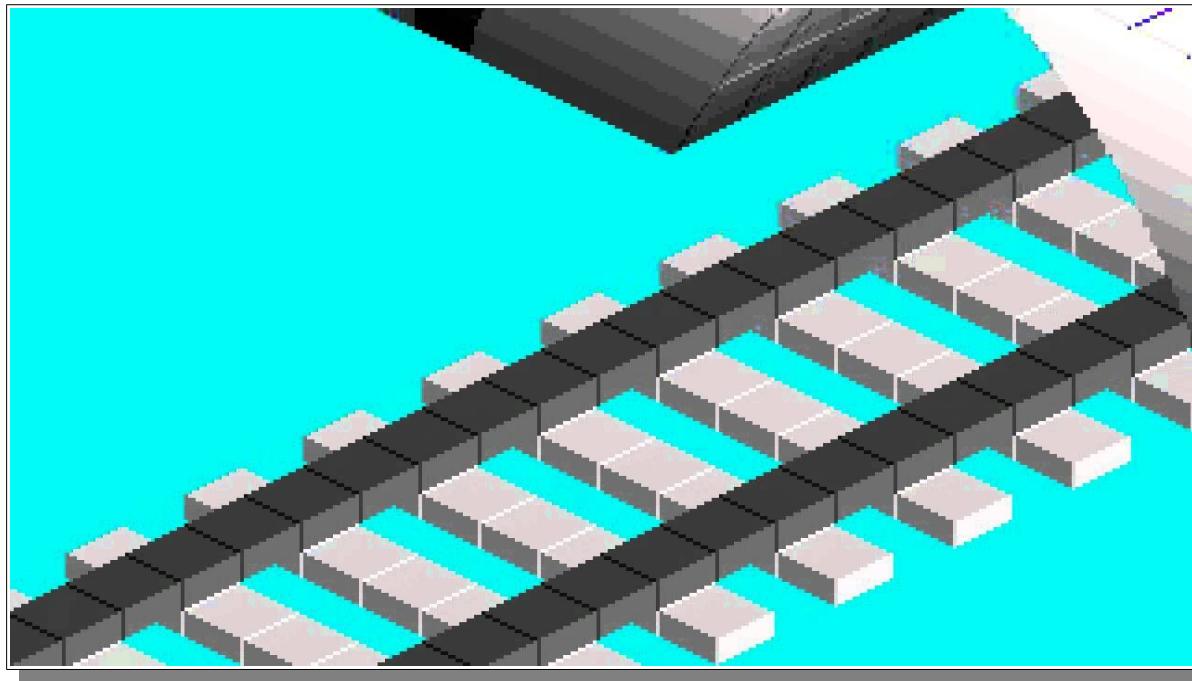
*Řrřola: Pyrit*

256-byte demoscene: extremly strong competition



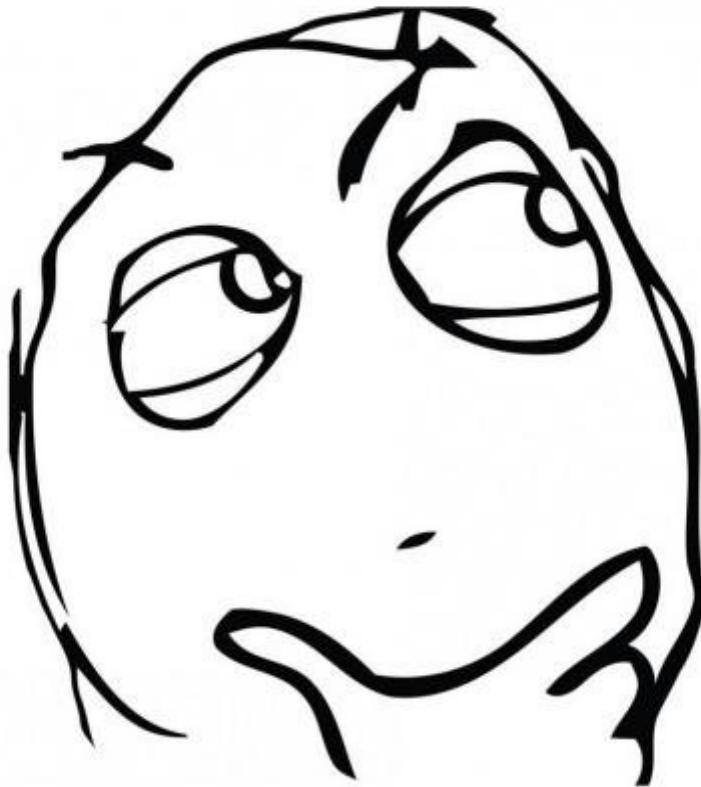
*Digimind: Pool Patrol*

256-byte demoscene: extremly strong competition



*Digimind: Immediate Railways*

256-byte demoscene: extremly strong competition



How to shine out of crowd?

# 256-byte demoscene: how to beat competition?

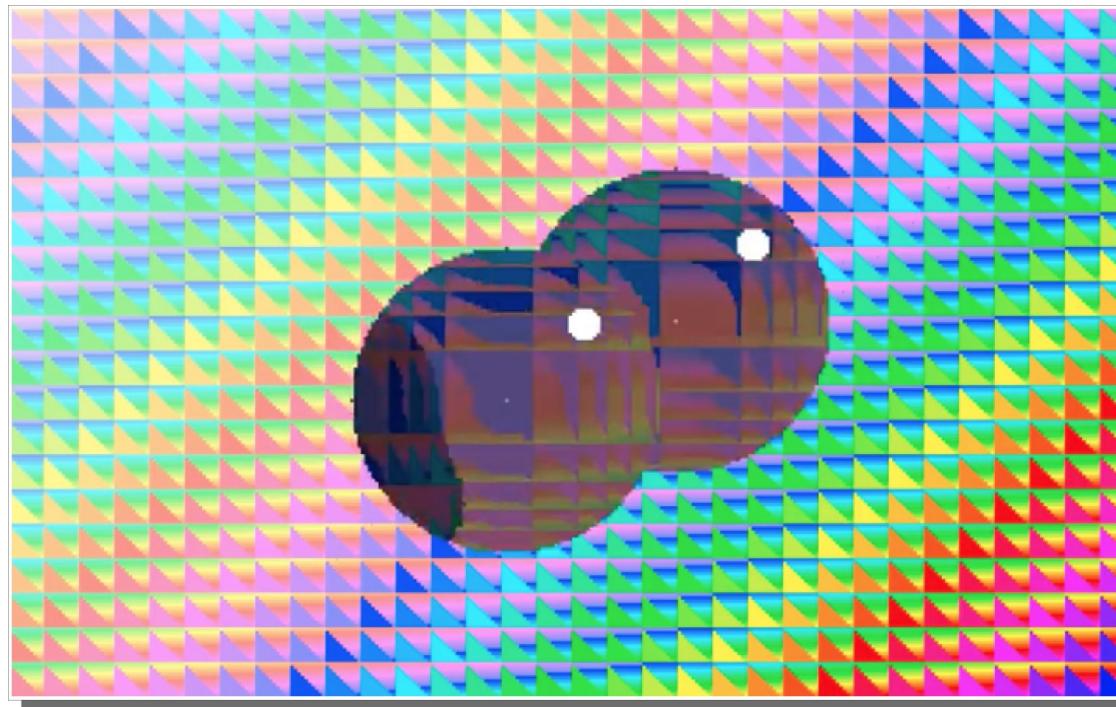
## Image processing



*TomCat: She – Weak Signal*

# 256-byte demoscene: how to beat competition?

## Raytracing



*TomCat: Spectrum Rulez!*

# 256-byte demoscene: how to beat competition?

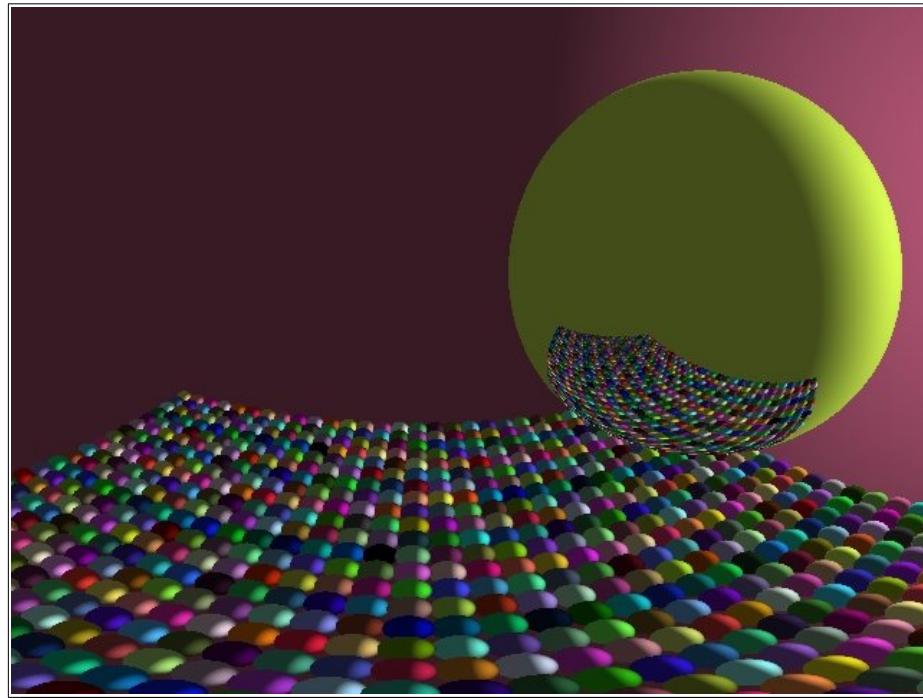
## Raytracing



*TomCat: Pokeball*

# 256-byte demoscene: how to beat competition?

## Raytracing

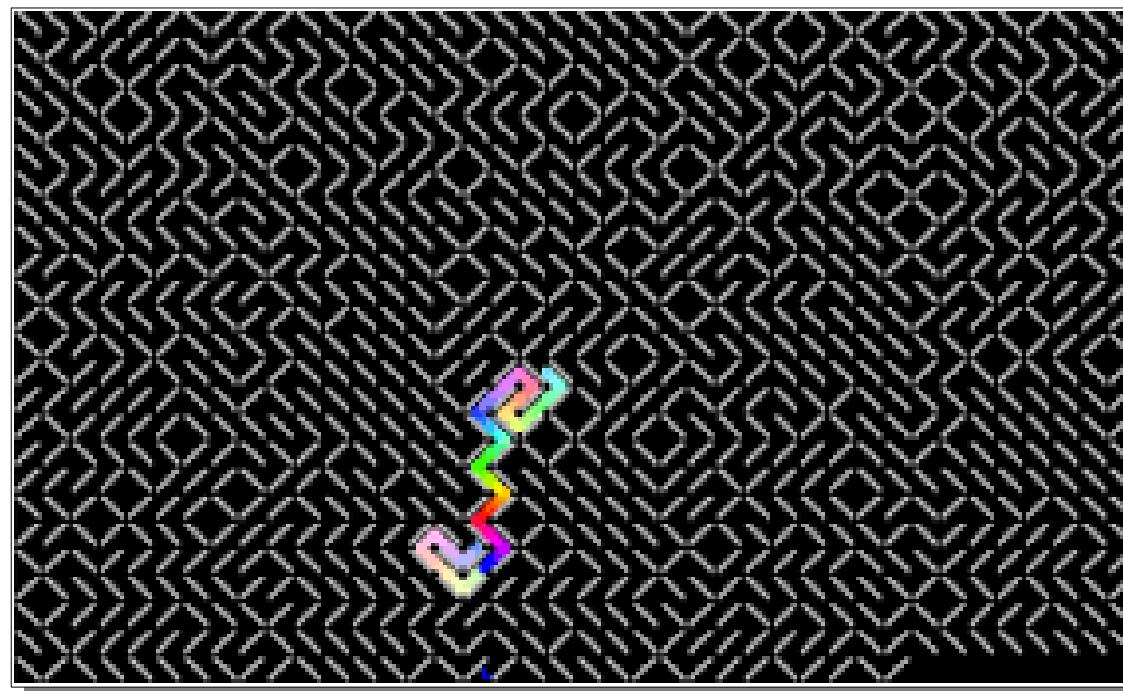


*TomCat: Colorful*

# 256-byte demoscene: how to beat competition?

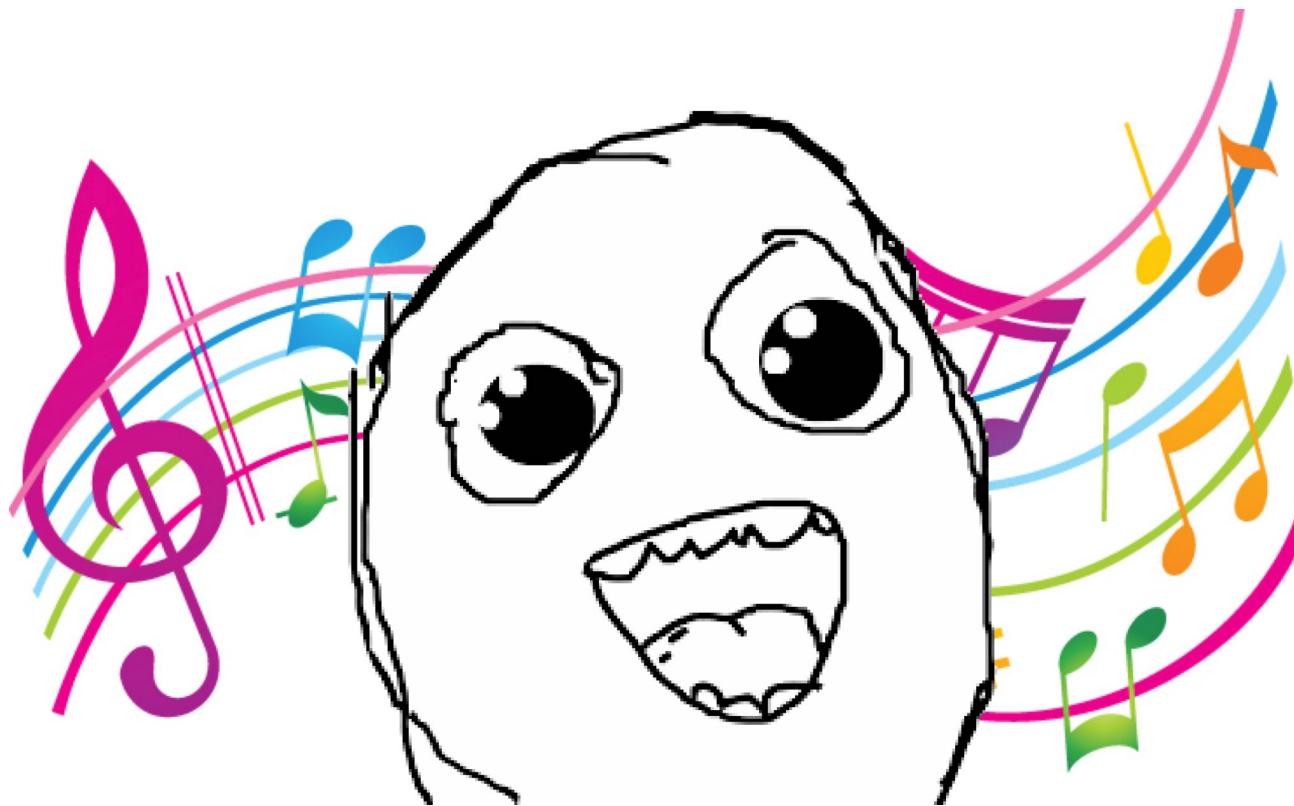
## Fun

(if you are not a hardcore sizecoder)



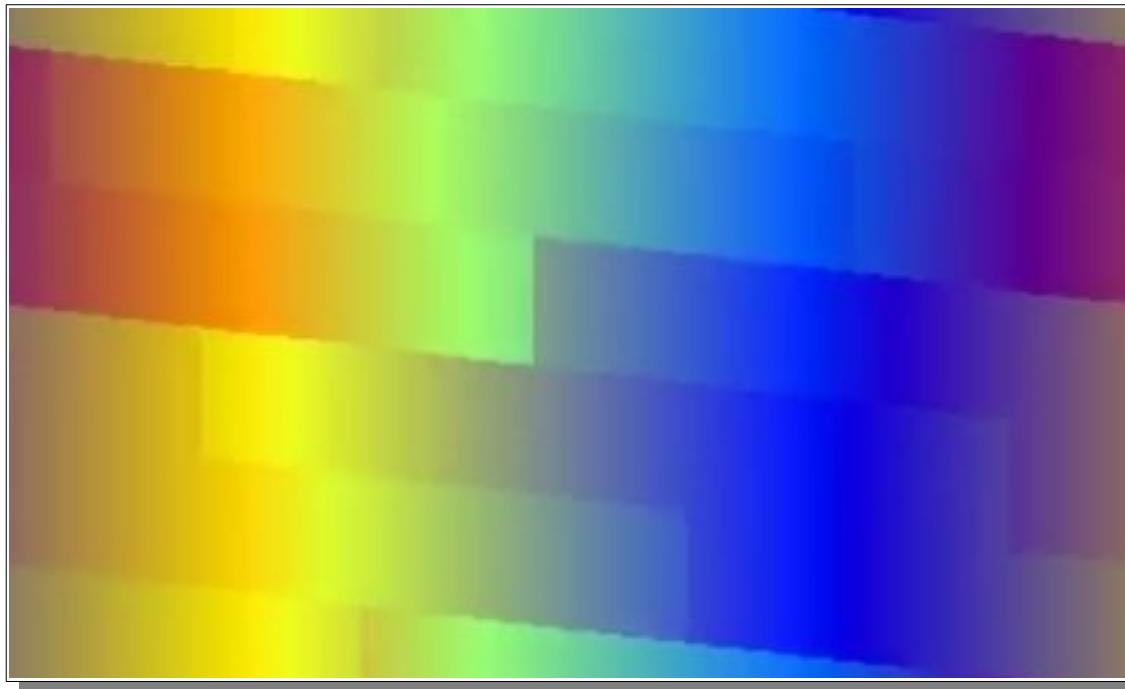
*ern0: Maze Solver*

# 256-byte demoscene: how to beat competition?



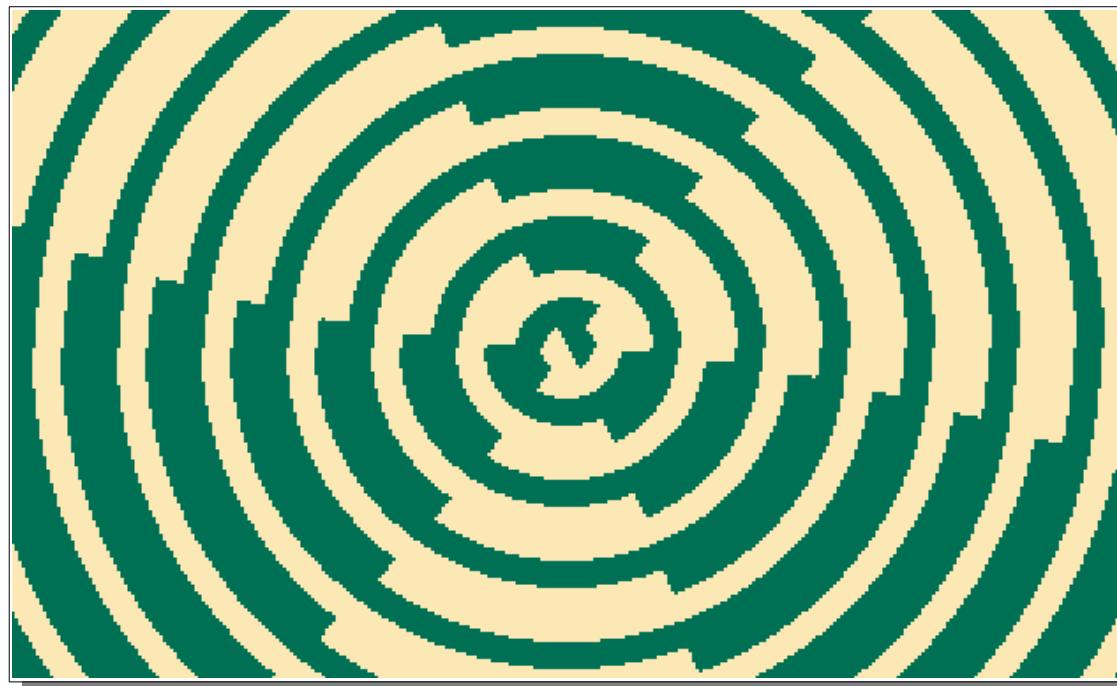
Music! Add music in 256-byte intros!

# 256 byte intro with music



*TomCat: 2(56)unlimited  
(bytebeat music by ern0)*

# 256 byte intro with music



*TomCat: No Sleep!*  
*(buzzer music by ern0)*

256 byte intro with music

Everyone loves it!



# Create universal bytebeat tool

# Create universal bytebeat tool

- Bytebeat player & editor

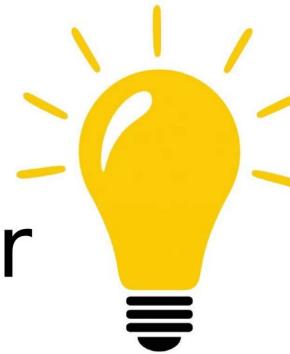
*TomCat*



# Create universal bytebeat tool

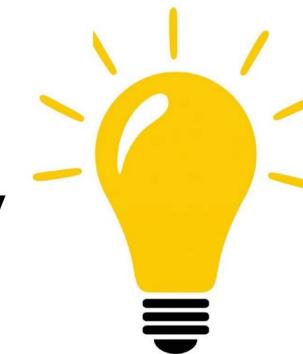
- Bytebeat player & editor

*TomCat*



- Formula compiler for assembly

*ern0*



# Create universal bytebeat tool

- Bytebeat player & editor  
*TomCat*
- Formula compiler for assembly  
*ern0*



# Create universal bytebeat tool

- Bytebeat player & editor

*TomCat*



- Formula compiler for assembly

*ern0*



# Bytebeat Editor (TomCat)

...

# Assemblyzator (ern0)

Transform bytebeat formula to assembly code...

## Assemblyzator (ern0)

Transform bytebeat formula to assembly code  
...using a modern C compiler!

# Assemblyzator (ern0)

Transform bytebeat formula to assembly code using a modern C compiler!

```
int main() {
    int result = 0;

    for (int i = 0; i < 100; i++) {
        for (int j = 0; j < 100; j++) {
            result += i * j;
        }
    }

    return result;
}
```

```
b8 e4 e0 75 01
5c3
```

```
main:
    mov     eax,0x175e0e4
    ret
```

# Assemblyzator (ern0)

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Very optimized!  
Such compiler!



# Assemblyzator (ern0)

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int main() {  
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 for (int j = 0; j < 100; j++) {  
 result += i \* j;  
 }  
 }  
  
 return result;  
}

b8 5c3 501 5c3 501  
 mov eax, 0x175e0e4  
 ret

~~Vc, optimized!  
such compiler!~~



No modern compiler exists for **16-bit** target.

# Assemblyzator (ern0)

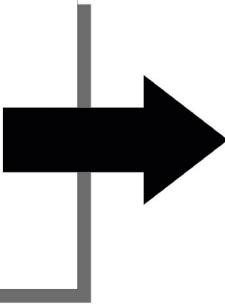
Let's write a compiler thing!

*Assemblyzator*

Split the complex bytebeat formula  
to series of simple formulas,  
which is close to assembly.

# Assemblyzator (ern0)

```
((t<<1) ^ ((t<<1) +  
(t>>7) &t>>12)) |  
t>>(4- (1^7&(t>>19)))  
| t>>7
```



```
var3 = t << 1  
var7 = t >> 7  
var5 = var3 + var7  
var6 = t >> 12  
var4 = var5 & var6  
var1 = var3 ^ var4  
var12 = t >> 19  
var11 = 7 & var12  
var10 = 1 ^ var11  
var9 = -var10  
var9 = var9 + 4  
var8 = t >> var9  
var2 = var8 | var7  
result = var1 | var2
```

# Assemblyzator (ern0)

## *Working:*

- split formula
- handle num arrays
- handle string arrays
- remove duplications

## *Design Flaws:*

- 3-op ( $A = B \text{ op } C$ )  
8086 assembly instructions are 2-operand
- can't handle cond. op.  
 $( A \text{ op } B ? C : D )$   
improperly designed Abstract Syntax Tree

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## *Summary:*

- nice try, but does not help much
- writing a compiler is not as easy as it looks first

# Assemblyzator (ern0)

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- handle num arrays
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Improperly designed Abstract Syntax Tree

## Summary:

- nice try, but it does not help much
- writing a compiler is not as easy as it looks first



[TomCat] *Instead of creating universal tools,  
we should choose one song and  
optimize for it*

[ern0] *Right, I'll pick a song*

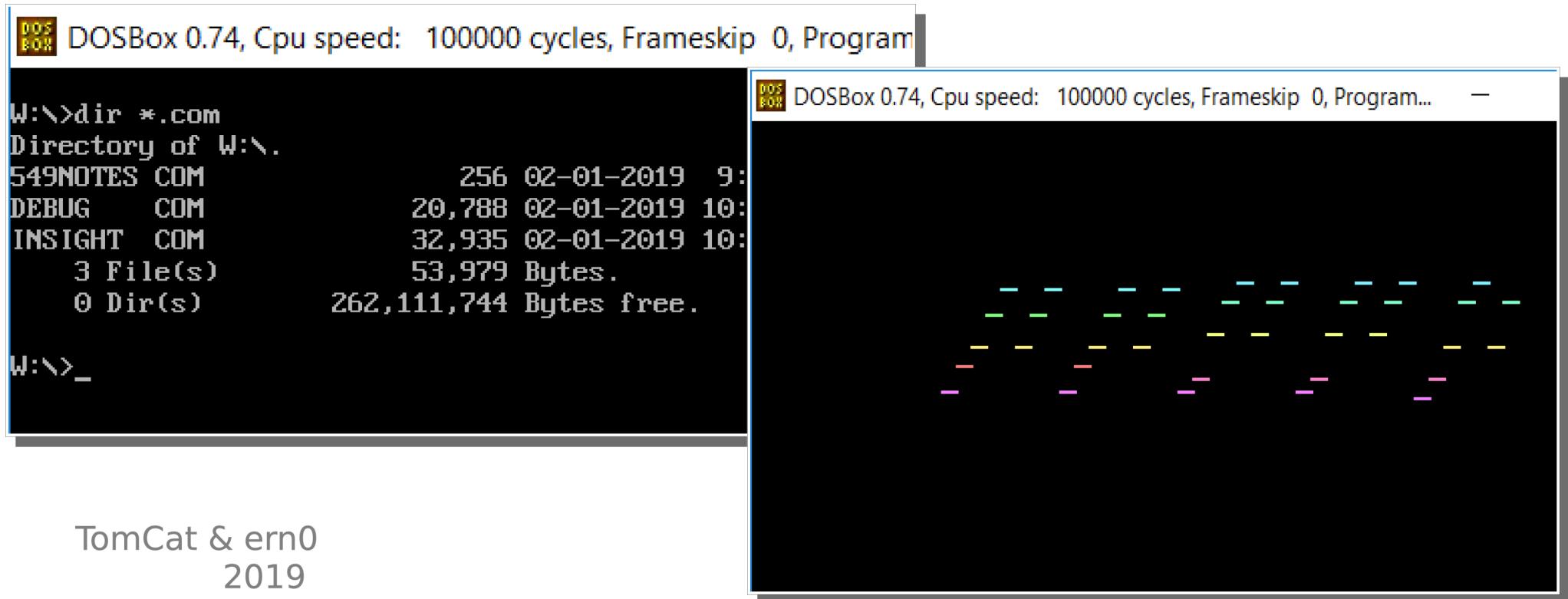


*Some hours later...*

[ern0] *I got the perfect one.*

# Making of **549NOTES.COM**

## the 256-byte intro for PC-DOS which plays 549 notes



## *Table Of Contents*

I. Song ★★★★☆

II. Data ★★★★★☆

III. Code ★★★★★★

# I. Song

# Prelude I

In C major

BWV 846

Johann Sebastian Bach (1685 - 1750)

Piano

This system shows the beginning of the prelude. The treble staff consists of eighth-note pairs followed by a rest. The bass staff consists of quarter notes with fermatas. The key signature is C major.

This system continues the pattern established in the first system. The treble staff has eighth-note pairs followed by rests. The bass staff has quarter notes with fermatas. A sharp sign appears in the key signature, indicating a temporary change to G major.

# *J. S. Bach: Prelude I. in C Major (BWV 846)*

1. Popular, well-known piece

# *J. S. Bach: Prelude I. in C Major (BWV 846)*

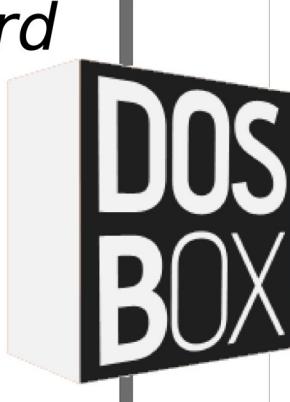
1. Popular, well-known piece
2. Written for piano: optimal for MIDI...

# J. S. Bach: Prelude I. in C Major (BWV 846)

- Piano (patch 1) is the default instrument on all channels for all General MIDI instruments
- Chord breaks: no „key up” message needed

*Switch sound card  
to MIDI mode:*

```
mov al,3fH  
mov dx,331H  
out dx,al
```



*Play a note:*

```
dec dx  
mov al,90H ; key down, ch=1  
out dx,al  
lodsb ; pitch  
out dx,al  
mov al,7fH ; velocity=127  
out dx,al
```

# *J. S. Bach: Prelude I. in C Major (BWV 846)*

1. Popular, well-known piece
2. Written for piano: optimal for MIDI
3. Simple rhythm, only a few tempo changes...

# *J. S. Bach: Prelude I. in C Major (BWV 846)*

Tempo changes:

- slow down around the end
- set minimal pause for the last 5-note chord

## *J. S. Bach: Prelude I. in C Major (BWV 846)*

1. Popular, well-known piece
2. Written for piano: optimal for MIDI
3. Simple rhythm, only a few tempo changes
4. Contains repeating patterns...

J. S. Bach: *Prelude I. in C Major (BWV 846)*

Repeating patterns 1/2:

Piano

The musical score displays two staves for a piano. The top staff uses a treble clef and a common time signature (indicated by a '4'). The bottom staff uses a bass clef and a common time signature. Both staves feature a key signature of one sharp (F#). The music consists of repeating eighth-note patterns. In each measure, there is a sixteenth note followed by a sixteenth note tied to a sixteenth note, with a short rest. This pattern repeats four times in the top staff and three times in the bottom staff.

# J. S. Bach: Prelude I. in C Major (BWV 846)

Repeating patterns 1/2:

Piano

The image shows two staves of a piano musical score. The top staff is in treble clef and the bottom staff is in bass clef. Both staves are in common time (indicated by '4'). The music consists of eighth-note patterns. The first staff has four measures highlighted with green circles, followed by four measures highlighted with blue circles, and then four measures highlighted with pink circles. The second staff has four measures highlighted with green circles, followed by four measures highlighted with red circles, and then four measures highlighted with purple circles. The piano dynamic 'pp' (pianissimo) is indicated at the beginning of each measure.

J. S. Bach: *Prelude I. in C Major (BWV 846)*

Repeating patterns 1/2:

Piano

A musical score for piano in 4/4 time. The treble and bass staves show a series of 16th-note patterns. The first four measures are highlighted with a green oval, the next four with a blue oval, and the final four with a pink oval. Measures 1-4: Treble staff has eighth-note pairs (B, A), (G, F#), (E, D), (C, B). Bass staff has eighth-note pairs (D, C), (F, E), (A, G), (C, B). Measures 5-8: Treble staff has eighth-note pairs (A, G), (F, E), (D, C), (B, A). Bass staff has eighth-note pairs (C, B), (E, D), (G, F#), (B, A). Measures 9-12: Treble staff has eighth-note pairs (G, F#), (E, D), (C, B), (A, G). Bass staff has eighth-note pairs (B, A), (D, C), (F, E), (A, G).

**16 → 8**

A continuation of the musical score. The first four measures are highlighted with a green oval, the next four with a red oval, and the final four with a purple oval. Measures 1-4: Treble staff has eighth-note pairs (B, A), (G, F#), (E, D), (C, B). Bass staff has eighth-note pairs (D, C), (F, E), (A, G), (C, B). Measures 5-8: Treble staff has eighth-note pairs (A, G), (F, E), (D, C), (B, A). Bass staff has eighth-note pairs (C, B), (E, D), (G, F#), (B, A). Measures 9-12: Treble staff has eighth-note pairs (G, F#), (E, D), (C, B), (A, G). Bass staff has eighth-note pairs (B, A), (D, C), (F, E), (A, G).

J. S. Bach: *Prelude I. in C Major (BWV 846)*

Repeating patterns 2/2:

Piano

The musical score consists of two staves for piano. The top staff is in common time (4/4) and the bottom staff is also in common time (4/4). Both staves feature a repeating pattern of eighth-note pairs followed by a sixteenth-note pair, with a bass note on the first beat of each measure. The pattern repeats six times in the top staff and five times in the bottom staff.

J. S. Bach: *Prelude I. in C Major (BWV 846)*

Repeating patterns 2/2:

Piano

The image displays two staves of a musical score for piano, labeled "Piano" on the left. The top staff is in common time (indicated by a "4") and the bottom staff is in common time (indicated by a "4"). Both staves begin with a bass clef (F) and a treble clef (G). The music consists of eighth-note patterns. In the first measure, the right hand has a pattern of eighth notes (purple shading) followed by a bass note. The left hand has a sustained bass note. This pattern repeats three times. In the fourth measure, the right hand begins a new pattern of eighth notes (green shading), while the left hand continues its sustained bass note. The pattern then repeats once more. The bottom staff follows a similar sequence, starting with a different eighth-note pattern (blue shading) in the first measure. It also features a sustained bass note from the left hand. This pattern repeats three times, followed by a new pattern (yellow shading) in the fourth measure, which then repeats once more.

J. S. Bach: *Prelude I. in C Major (BWV 846)*

Repeating patterns 2/2:

Piano

A musical score for piano in 4/4 time. The treble clef is on the top staff, and the bass clef is on the bottom staff. The score consists of two measures. The first measure contains six eighth notes in the treble clef, grouped into three pairs by vertical stems. The second measure contains five eighth notes in the treble clef, grouped into two pairs by vertical stems. The bass staff shows sustained notes with fermatas. The notes are highlighted with purple and green color overlays.

**8 → 5**

A musical score for piano in 4/4 time. The treble clef is on the top staff, and the bass clef is on the bottom staff. The score consists of two measures. The first measure contains six eighth notes in the treble clef, grouped into three pairs by vertical stems. The second measure contains five eighth notes in the treble clef, grouped into two pairs by vertical stems. The bass staff shows sustained notes with fermatas. The notes are highlighted with blue, yellow, and red color overlays.

# Raw Data

<i>part</i>	<i>effective notes</i>	<i>raw data</i>
<i>repeating</i>	512	160
<i>non-repeating</i>	32	32
<i>final chord</i>	5	5
<b><i>total</i></b>	<b>549</b>	<b>197</b>



## II. Data

# **II. Data Compression**