

# Replicode tutorial: Dynamic Code Production example

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# In this tutorial

- An simple example of dynamic code production is analyzed
- The program creates and instansiates a program template (class) at run-time
- **Markers** are introduced
- Concepts, commands and syntax that have not been covered by previous tutorials are explained as they occur

# Example #3: Dynamic code production (test.16.replicode)

```
_start:(pgm  
|[]  
|[]  
|[]
```

Create a program template and label it as **\_start**. This program does not require template arguments or specific inputs, hence the empty sets.



```
_start:(pgm
[]
[]
[]
(inj [] ←
  p:(pgm
```

The first command in the productions section is an injection. But now, we are injecting a new program template, labelled as **p**.



```

_start:(pgm
  []
  []
  []
  (inj []
    p:(pgm
      []
      []
      []
      (inj []
        (mk.val self position (vec 3 1 2 3) 1)

```

Our new program template requires no template arguments or inputs.

The first command in the productions section of the new program is to inject a **marker**. Markers are special objects that encode relations. This particular marker encodes a relationship between the self entity and the position entity (both defined in the file “**user.classes.replicode**”). The position entity can be considered a dummy entity to represent the concept of position while the self entity refers to the Replicode system itself. The relationship between the two is represented as a three dimensional vector. What this marker says is essentially: “The value of *position* for *self* is the 3D vector (1,2,3)”.



```

_start:(pgm
  []
  []
  []
  (inj []
    p:(pgm
      []
      []
      []
      (inj []
        (mk.val self position (vec3 1 2 3) 1)
        [SYNC_FRONT (\ (+ now 10000)) 1]
        forever root nil]
      )
      (mod [this.vw.act -1])
      1
    )
    [SYNC_FRONT now 1 forever root nil]
  )
  (inj []
    (ins p |[] RUN_ALWAYS 50000us NOTIFY)
    [SYNC_FRONT now 1 forever root nil]
  )
  1
)
|[]

```

The view for the new marker. Specifies root as the target group, that the marker shall never be automatically deleted and that it shall be created after 10000 microseconds.

After the marker injection, the program sets its activation to zero, essentially killing itself.

After the marker injection, the program sets its activation to zero, essentially killing itself.

Create an instance of the program **p**. It should create notifications and run no more than once every 50000 microseconds. This instance will be injected into the root group.

```

_start:(pgm
  []
  []
  []
  (inj []
    p:(pgm
      []
      []
      []
      (inj []
        (mk.val self position (vec3 1 2 3) 1)
        [SYNC_FRONT (\ (+ now 10000)) 1 forever
root nil]
      )
      (mod [this.vw.act -1])
      1
      )
      [SYNC_FRONT now 1 forever root nil]
      )
      (inj []
        (ins p [] RUN_ALWAYS 50000us NOTIFY)
        [SYNC_FRONT now 1 forever root nil 1]
        )
      1
      )
      []
i_start:(ipgm _start [] RUN_ONCE 90000us
NOTIFY 1)
[]
  [SYNC_FRONT now 1 1 root nil 1]

```

Create an instance of the program **\_start** and inject to the root group. For this instance, the resilience is set to 1 (as opposed to “forever”), this means that the program will decay and eventually be deleted barring some intervention.



```

compiling ...
usr operators initialized
> User-defined operator library ./usr_operators.dll loaded
... done

Running for 1000 ms

Shutting rMem down...

DECOMPILED

root:(grp 1 0.5 0.4 0 1 0 1 0 0 0 1 0 1 1 1 1 0.690909 1 0
7.05297e-038 9.40395e
-038 0 1 0 1 1 0 1 0 0 [nil] 1) []
[true (_now) 0 forever nil nil false 0]

grp0:(grp 1 0 0 1 0 1 0 1 0 -0.2 0 0 0 1 2 1 1 0 0 0 9.40396e-038
9.40396e-038 1 1
0 1 1 0 1 0 0 [nil] 1) []
[true 0s:0ms:0us 0 forever root nil false 0]

stdin:(grp 1 0 0 0 1 0 1 0 0 1 0 0 1 1 1 1 0 0 1 0 0 1 1 0 1 1 0 1 0
0 [root] 1)
[]
[true 0s:0ms:0us 0 forever grp0 nil true 1]
[true 0s:0ms:0us 0 forever root nil false 0]

stdout:(grp 1 0 0 0 1 0 1 0 0 1 0 1 1 1 1 0 0 1 0 0 1 1 0 1 1 0 1
0 0 [nil] 1)
[]
[true 0s:0ms:0us 0 forever root nil false 0]

self:(ent 0.95) []
[true 0s:0ms:0us 0.6 forever root nil]

mk.val0:(mk.val self ent0 (vec3 1 2 3) 1) []
[true 0s:152ms:818us 1 forever root root]

ent0:(ent 1) []
[true 0s:0ms:0us 1 forever root nil]

pgm0:(pgm |[] |[] []
(cmd_inj 0xa1000000 []
v0:(pgm |[] |[] []
(cmd_inj 0xa1000000 []
(mk.val self ent0 (vec3 1 2 3) 1)
[true (syn (add (_now) 10000)) 1 forever root nil]
)
(cmd_mod 0xa1000000 []
this.vw.act
-1
)
)
1)
[true (_now) 1 forever root nil]
)
(cmd_inj 0xa1000000 []
(ins v0 |[] true 2854220939s:17ms:316us true)
[true (_now) 1 forever root nil 1]
)
)
1) |[]

```

```

pgm1:(pgm |[] |[] []
(cmd_inj 0xa1000000 []
(mk.val self ent0 (vec3 1 2 3) 1)
[true (add (_now) 10000) 1 forever root nil]
)
)
(cmd_mod 0xa1000000 []
this.vw.act
-1
)
)
1) |[]
[true 0s:91ms:251us 1 forever root root]

ipgm0:(ipgm pgm1 |[] true 0s:50ms:0us true 1) []
[true 0s:91ms:633us 1 forever root root 0]

mk.rdx0:(mk.rdx ipgm1 |[] []
(cmd_inj 0xa1000000 []
pgm1
[true 0s:89ms:943us 1 forever root nil]
)
)
(cmd_inj 0xa1000000 []
ipgm0
[true 0s:91ms:13us 1 forever root nil 1]
)
)
1) |[]
[true 0s:92ms:509us 1 991 root root]

ipgm1:(ipgm pgm0 |[] false 0s:90ms:0us true 1) |[]

mk.rdx1:(mk.rdx ipgm0 |[] [(cmd_inj 0xa1000000 []
mk.val0
[true 0s:151ms:862us 1 forever root nil]
)] 1) |[]
[true 0s:143ms:166us 1 992 root root]

mk.rdx2:(mk.rdx ipgm0 |[] [(cmd_inj 0xa1000000 []
mk.val0
[true 0s:203ms:874us 1 forever root nil]
)] 1) |[]
[true 0s:195ms:273us 1 992 root root]

Image taken at: Tue Mar 15 2011 12:01:51:590:271 GMT
14 objects

```

This is the output generated when the program is executed. Note that the output is not ordered temporally. For example, **ipgm1** (instance of `_start`) is clearly created before **ipgm0** (instance of `p`) but still occurs later in the output.

```

compiling ...
usr operators initialized
> User-defined operator library ./usr_operators.dll loaded
... done

Running for 1000 ms

Shutting rMem down...

DECOMPILED

root:(grp 1 0.5 0.4 0 1 0 1 0 0 0 1 0 1 1 1 1 0.690909 1 0
7.05297e-038 9.40395e
-038 0 1 0 1 1 0 1 0 0 [nil] 1) []
[true (_now) 0 forever nil nil false 0]

grp0:(grp 1 1 0 0 1 0 1 0 -0.2 0 0 0 1 2 1 1 0 0 0 9.40396e-038
9.40396e-038 1 1
0 1 1 0 1 0 0 [nil] 1) []
[true 0s:0ms:0us 0 forever root nil false 0]

stdin:(grp 1 0 0 0 1 0 1 0 0 1 0 0 1 1 1 1 0 0 1 0 0 1 1 0 1 0 1 0
0 [root] 1)
[]
[true 0s:0ms:0us 0 forever grp0 nil true 1]
[true 0s:0ms:0us 0 forever root nil false 0]

stdout:(grp 1 0 0 0 1 0 1 0 0 1 0 1 1 1 1 0 0 1 0 0 1 1 0 1 1 0 1
0 0 [nil] 1)
[]
[true 0s:0ms:0us 0 forever root nil false 0]

self:(ent 0.95) []
[true 0s:0ms:0us 0.6 forever root nil]

mk.val0:(mk.val self ent0 (vec3 1 2 3) 1) []
[true 0s:152ms:818us 1 forever root root]

ent0:(ent 1) []
[true 0s:0ms:0us 1 forever root nil]

pgm0:(pgm |[] |[] []
(cmd_inj 0xa1000000 []
v0:(pgm |[] |[] []
(cmd_inj 0xa1000000 []
(mk.val self ent0 (vec3 1 2 3) 1)
[true (syn (add (_now) 10000)) 1 forever root nil]
)
(cmd_mod 0xa1000000 []
this.vw.act
-1
)
1)
[true (_now) 1 forever root nil]
)
(cmd_inj 0xa1000000 []
(mk.val self ent0 (vec3 1 2 3) 1)
[true (_now) 1 forever root nil 1]
)
1) |[]

```

```

pgm1:(pgm |[] |[] []
(cmd_inj 0xa1000000 []
(mk.val self ent0 (vec3 1 2 3) 1)
[true (add (_now) 10000) 1 forever root nil]
)
(cmd_mod 0xa1000000 []
this.vw.act
-1
)
1) |[]
[true 0s:91ms:251us 1 forever root root]

ipgm0:(ipgm pgm1 |[] true 0s:50ms:0us true 1) []
[true 0s:91ms:633us 1 forever root root 0]

mk.rdx0:(mk.rdx ipgm1 |[] []
(cmd_inj 0xa1000000 []
pgm1
[true 0s:89ms:943us 1 forever root nil]
)
(cmd_inj 0xa1000000 []
ipgm0
[true 0s:91ms:13us 1 forever root nil 1]
)
1) |[]
[true 0s:92ms:509us 1 991 root root]

ipgm1:(ipgm pgm0 |[] false 0s:90ms:0us true 1) |[]

mk.rdx1:(mk.rdx ipgm0 |[] [(cmd_inj 0xa1000000 []
mk.val0
[true 0s:151ms:862us 1 forever root nil]
)] 1) |[]
[true 0s:143ms:166us 1 992 root root]

mk.rdx2:(mk.rdx ipgm0 |[] [(cmd_inj 0xa1000000 []
mk.val0
[true 0s:203ms:874us 1 forever root nil]
)] 1) |[]
[true 0s:195ms:273us 1 992 root root]

Image taken at: Tue Mar 15 2011 12:01:51:590:271 GMT
14 objects

```

The template for the program **\_start** is highlighted as well as its only instance.



```
compiling ...
usr operators initialized
> User-defined operator library ./usr_operators.dll loaded
... done
```

```
Running for 1000 ms
```

```
Shutting rMem down...
```

```
DECOMPILE
```

```
root:(grp 1 0.5 0.4 0 1 0 1 0 0 0 1 0 1 1 1 1 0.690909 1 0
7.05297e-038 9.40395e
-038 0 1 0 1 1 0 1 0 0 [nil] 1) []
[true (_now) 0 forever nil nil false 0]
```

```
grp0:(grp 1 0 0 1 0 1 0 1 0 -0.2 0 0 0 1 2 1 1 0 0 0 9.40396e-038
9.40396e-038 1 1
0 1 1 0 1 0 0 [nil] 1) []
[true 0s:0ms:0us 0 forever root nil false 0]
```

```
stdin:(grp 1 0 0 0 1 0 1 0 0 1 0 0 1 1 1 1 0 0 1 0 0 1 1 0 1 1 0 1 0
0 [root] 1)
[]
[true 0s:0ms:0us 0 forever grp0 nil true 1]
[true 0s:0ms:0us 0 forever root nil false 0]
```

```
stdout:(grp 1 0 0 0 1 0 1 0 0 1 0 1 1 1 1 0 0 1 0 0 1 1 0 1 1 0 1
0 0 [nil] 1)
[]
[true 0s:0ms:0us 0 forever root nil false 0]
```

```
self:(ent 0.95) []
[true 0s:0ms:0us 0.6 forever root nil]
```

```
mk.val0:(mk.val self ent0 (vec3 1 2 3) 1) []
[true 0s:152ms:818us 1 forever root root]
```

```
ent0:(ent 1) []
[true 0s:0ms:0us 1 forever root nil]
```

```
pgm0:(pgm [] [] [] []
(cmd_inj 0xa1000000 []
v0:(pgm [] [] [] []
(cmd_inj 0xa1000000 []
(mk.val self ent0 (vec3 1 2 3) 1)
[true (syn (add (_now) 10000)) 1 forever root nil]
)
(cmd_mod 0xa1000000 []
this.vw.act
-1
)
)
1)
[true (_now) 1 forever root nil]
)
(cmd_inj 0xa1000000 []
(ins v0 [] true 2854220939s:17ms:316us true)
[true (_now) 1 forever root nil 1]
)
)
1) []
```

```
pgm1:(pgm [] [] [] []
(cmd_inj 0xa1000000 []
(mk.val self ent0 (vec3 1 2 3) 1)
[true (add (_now) 10000) 1 forever root nil]
)
(cmd_mod 0xa1000000 []
this.vw.act
-1
)
)
1) []
[true 0s:91ms:251us 1 forever root root]
```

```
ipgm0:(ipgm pgm1 [] true 0s:50ms:0us true 1) []
[true 0s:91ms:633us 1 forever root root 0]
```

```
mk.rdx0:(mk.rdx ipgm1 [] [] []
(cmd_inj 0xa1000000 []
pgm1
[true 0s:89ms:943us 1 forever root nil]
)
(cmd_inj 0xa1000000 []
ipgm0
[true 0s:91ms:13us 1 forever root nil 1]
)
)
1) []
[true 0s:92ms:509us 1 991 root root]
```

```
ipgm1:(ipgm pgm0 [] false 0s:90ms:0us true 1) []
```

```
mk.rdx1:(mk.rdx ipgm0 [] [(cmd_inj 0xa1000000 []
mk.val0
[true 0s:151ms:862us 1 forever root nil]
)] 1) []
[true 0s:143ms:166us 1 992 root root]
```

```
mk.rdx2:(mk.rdx ipgm0 [] [(cmd_inj 0xa1000000 []
mk.val0
[true 0s:203ms:874us 1 forever root nil]
)] 1) []
[true 0s:195ms:273us 1 992 root root]
```

```
Image taken at: Tue Mar 15 2011 12:01:51:590:271 GMT
```

```
14 objects
```

The template definition for the program **p** is highlighted as well as the instantiation. Both were created by the program **\_start** (pgm0). The corresponding notification (reduction marker) is also highlighted.

```

compiling ...
usr operators initialized
> User-defined operator library ./usr_operators.dll loaded
... done

Running for 1000 ms

Shutting rMem down...

DECOMPILED

root:(grp 1 0.5 0.4 0 1 0 1 0 0 0 1 0 1 1 1 1 0.690909 1 0
7.05297e-038 9.40395e
-038 0 1 0 1 1 0 1 0 0 [nil] 1) []
[true (_now) 0 forever nil nil false 0]

grp0:(grp 1 1 0 0 1 0 1 0 0 -0.2 0 0 0 1 2 1 1 0 0 0 9.40396e-038
9.40396e-038 1 1
0 1 1 0 1 0 0 [nil] 1) []
[true 0s:0ms:0us 0 forever root nil false 0]

stdin:(grp 1 0 0 0 1 0 1 0 0 1 0 0 1 1 1 1 0 0 1 0 0 1 1 0 1 1 0 1 0
0 [root] 1)
[]
[true 0s:0ms:0us 0 forever grp0 nil true 1]
[true 0s:0ms:0us 0 forever root nil false 0]

stdout:(grp 1 0 0 0 1 0 1 0 0 1 0 1 1 1 1 0 0 1 0 0 1 1 0 1 1 0 1 0
0 0 [nil] 1)
[]
[true 0s:0ms:0us 0 forever root nil false 0]

self:(ent 0.95) []
[true 0s:0ms:0us 0.6 forever root nil]

mk.val0:(mk.val self ent0 (vec3 1 2 3) 1) []
[true 0s:152ms:818us 1 forever root root]

ent0:(ent 1) []
[true 0s:0ms:0us 1 forever root nil]

pgm0:(pgm |[] |[] []
(cmd_inj 0xa1000000 []
v0:(pgm |[] |[] []
(cmd_inj 0xa1000000 []
(mk.val self ent0 (vec3 1 2 3) 1)
[true (syn (add (_now) 10000)) 1 forever root nil]
)
(cmd_mod 0xa1000000 []
this.vw.act
-1
)
)
1) []
[true (_now) 1 forever root nil]
)
(cmd_inj 0xa1000000 []
(ins v0 |[] true 2854220939s:17ms:316us true)
[true (_now) 1 forever root nil 1]
)
1) []]

```

```

pgm1:(pgm |[] |[] []
(cmd_inj 0xa1000000 []
(mk.val self ent0 (vec3 1 2 3) 1)
[true (add (_now) 10000) 1 forever root nil]
)
(cmd_mod 0xa1000000 []
this.vw.act
-1
)
)
1) []
[true 0s:91ms:251us 1 forever root root]

ipgm0:(ipgm pgm1 |[] true 0s:50ms:0us true 1) []
[true 0s:91ms:633us 1 forever root root 0]

mk.rdx0:(mk.rdx ipgm1 |[] []
(cmd_inj 0xa1000000 []
pgm1
[true 0s:89ms:943us 1 forever root nil]
)
(cmd_inj 0xa1000000 []
ipgm0
[true 0s:91ms:13us 1 forever root nil 1]
)
)
1) []
[true 0s:92ms:509us 1 991 root root]

ipgm1:(ipgm pgm0 |[] false 0s:90ms:0us true 1) []

mk.rdx1:(mk.rdx ipgm0 |[] [(cmd_inj 0xa1000000 []
mk.val0
[true 0s:151ms:862us 1 forever root nil]
)] 1) []
[true 0s:143ms:166us 1 992 root root]

mk.rdx2:(mk.rdx ipgm0 |[] [(cmd_inj 0xa1000000 []
mk.val0
[true 0s:203ms:874us 1 forever root nil]
)] 1) []
[true 0s:195ms:273us 1 992 root root]

Image taken at: Tue Mar 15 2011 12:01:51:590:271 GMT

14 objects

```

The marker created by ipgm0 (p) is highlighted along with the notification.



# In conclusion

- This example shows how to create new program templates at run-time
- Template arguments and inputs can be used in the construction of new program templates
  - Although not done in this example for clarity
- Do not assume any ordering in the output (decompiled image)