Mid-Air Plane Repair: Debugging in Production

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WhatsApp – What's Up?

#1 messaging app

- Android, iPhone, Windows Phone, JioPhone
- Web and native clients
- More than 1.5B monthly active users
- WhatsApp Business products
- Thousands of servers to maintain

Large Scale Deployment Problems

Testing does not replace troubleshooting

Uncontrolled Environment

Moving pieces

- Hardware
- Operating system
- Kernel version
- Shared libraries
- Running services
- Application components
- Code deployed and executed

Troubleshooting Workflow

Workflow

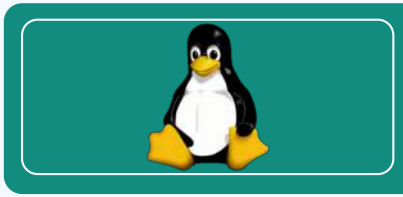
Detection: Monitoring, Alerts, Dashboards

Application & OTP

- Counters & Gauges, per node & aggregates
- Workers -> Factories -> Industries

Virtual Machine

- Internal: schedulers, allocators, queues, processes, ports, microstate accounting
- External: CPU, memory (RSS,VSZ), file descriptors, log file growth



OS, kernel, system applications

- atop data (+log files)
- perf samples (Strobelight)

Hardware Health

- CPU, RAM, NICs, PSU, sensors

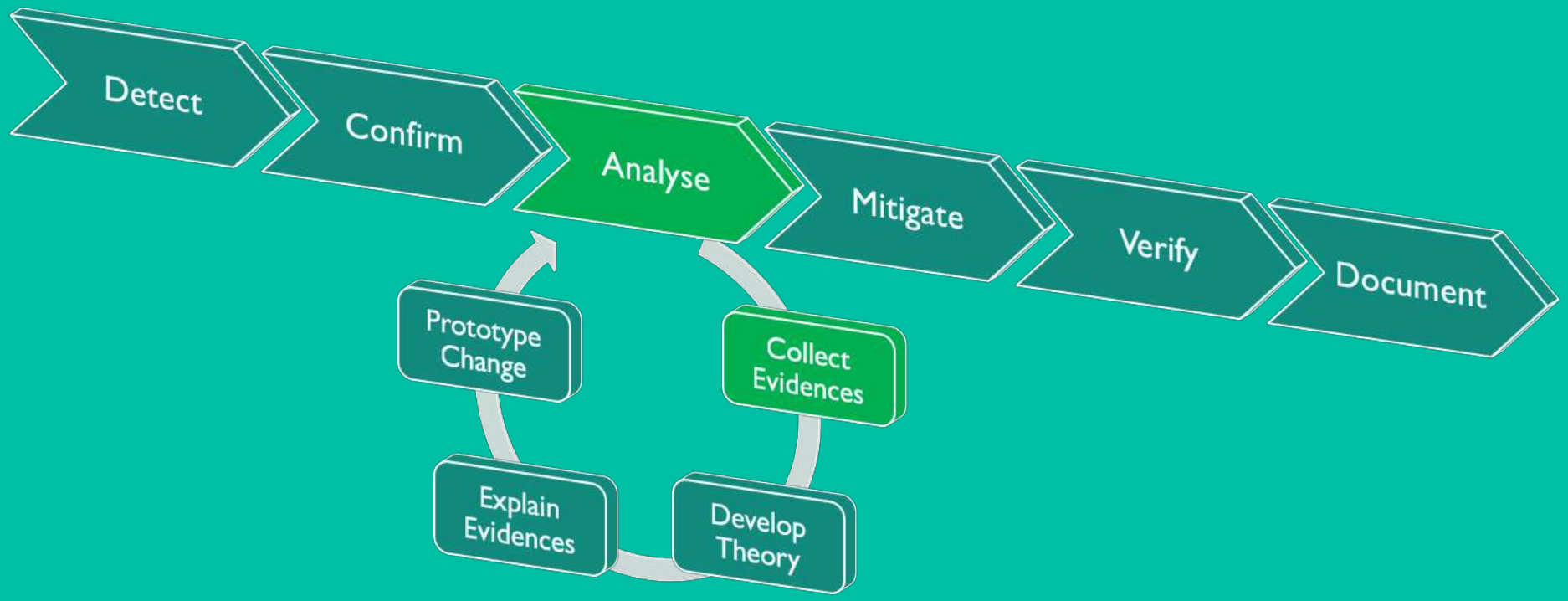
Workflow

Filter Out False Positives

Account for baseline changes

- Soccer matches (login/messages spikes)
- User base growth (640k is enough for everyone)
- Cluster size changes (more users, less servers?)
- BEAM configuration limits (pix table, atom table, etc.)

Workflow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Evidence Collection

Preserve as much as possible, store in a cool dry place

- Crash & core dumps
- Emulator error reports, supervisor reports
- Log files (including host logs, atop logs, kernel messages)
- External change logs and RPC audit

- Additional on-demand data
- High-resolution metrics timelines (counters, gauges)

ectl Framework

Quick look into system state

```
/home/whatsapp# ectl pi 54

Process <0.54.0> (inet_db):
 Current location is gen_server/loop:7 (gen_server.erl:403))
 Current function is gen_server/loop:7
 Message queue length is 112304
 Process size: 23247860 bytes (heap=6664208 stack=80 total=23246872)
 Current stack depth is 2:
  1: gen_server:loop/7 (gen_server.erl:403)
  2: proc_lib:init_p_do_apply/3 (proc_lib.erl:249)
 Dictionary
```

ectl: Connecting Unix Shell and Erlang

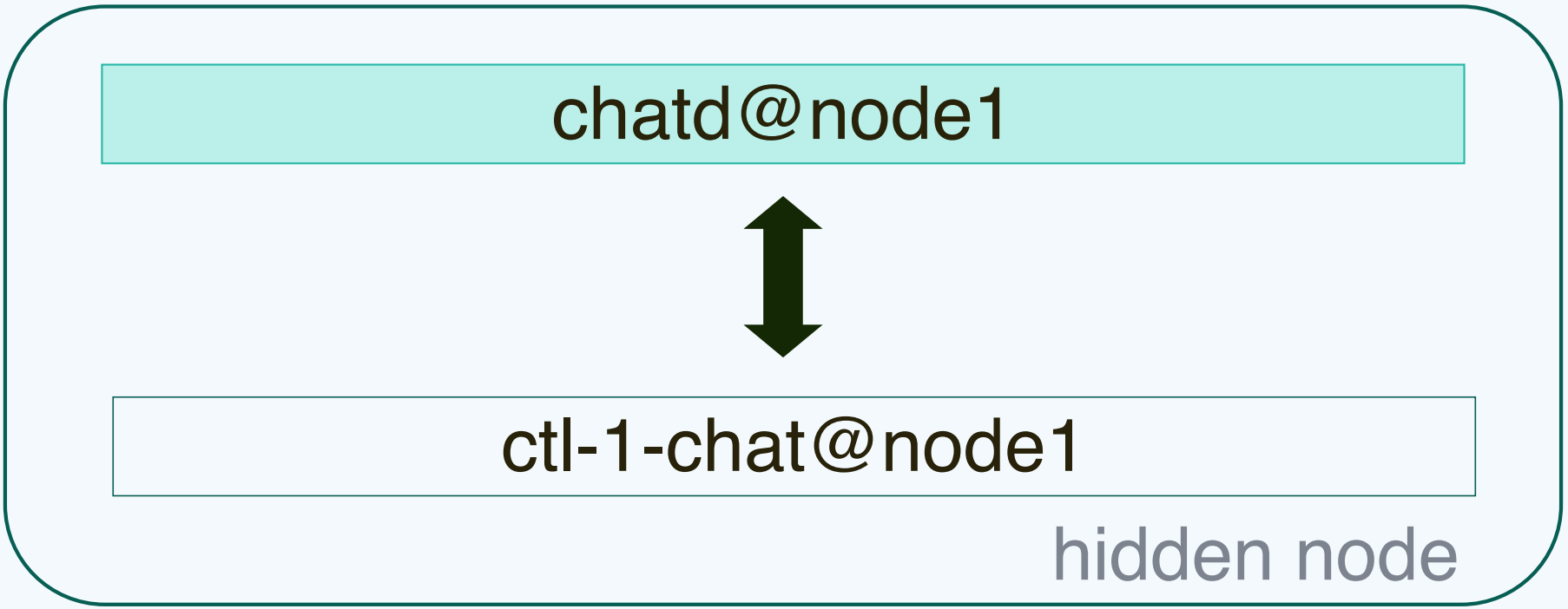
Validators, default values, usage

```
/home/whatsapp# ectl man load

load [MODULES]... [--force] [--background-purge] [--purge purge] [-a] [-d] [-s scope]
                          --  Code load specified module(s), using specific load order and scope
  MODULES string ...              -- Module name to load or force reload
  --force                         -- Forcefully purge modules with processes lingering in old code
  --background-purge              -- Perform asynchronous soft_purge, default: true
  --purge 0 <= purge <= 1000000   -- Load order: wait (ms) for old code to be purged after module
load, default: 30000
  -a, --all                       -- Load all modified modules after specified ones
  -d, --dry                       -- Prepares loading and prints load order, but does not load
  -s, --scope string              -- Perform a scoped operation, see 'ectl scoped_help' for
details
```

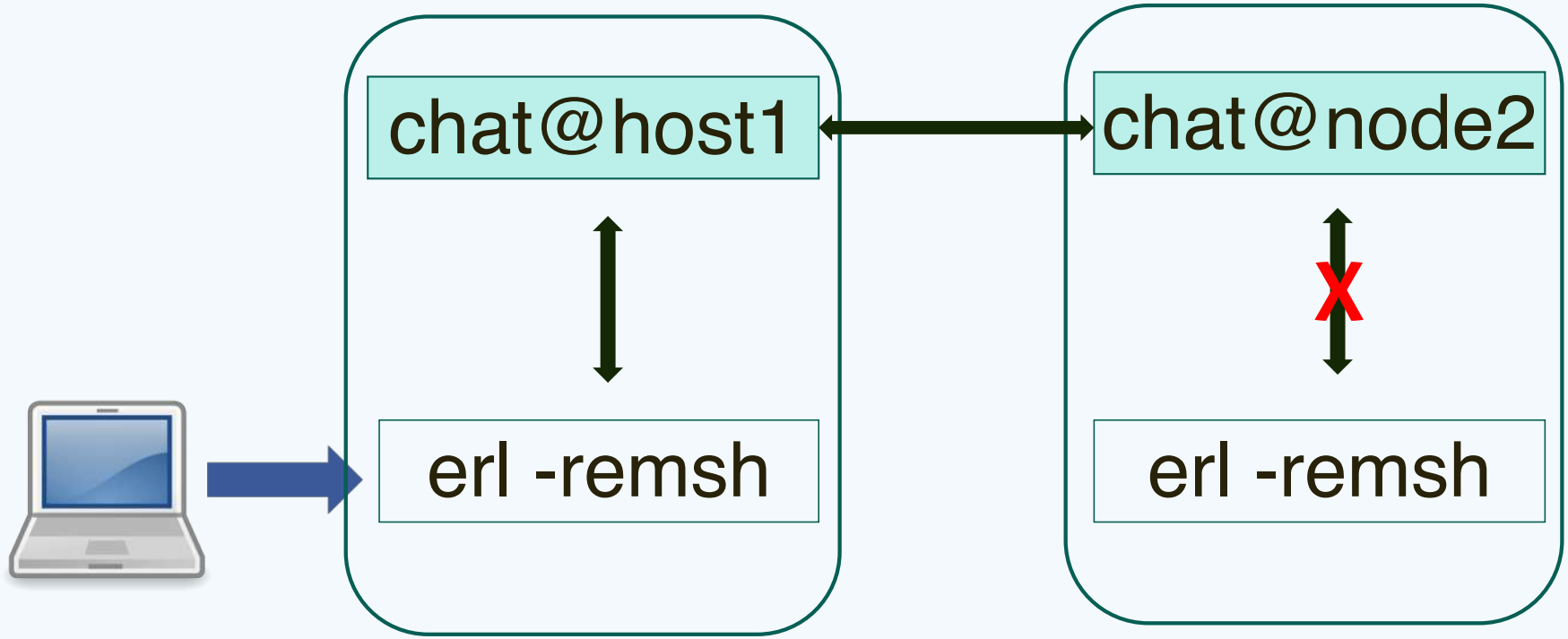
ectl: Just a Hidden Node

ectl, ejabberdctl successor, joins distribution cluster



Remote Shell

When deeper introspection is required



Erlang power_shell

Available on GitHub

```
Eshell V10.2  (abort with ^G)

1> dist_util:gen_challenge().
** exception error: undefined function dist_util:gen_challenge/0

2> eval(dist_util, gen_challenge, []).
558236439
```

OTP - Patching Shell

Syntax sugar makes a candy

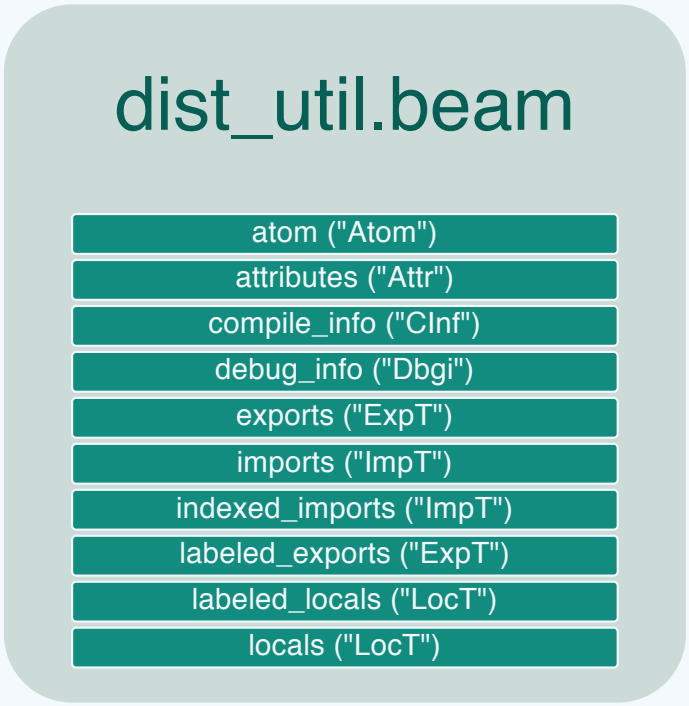
```
4> dist_util:gen_challenge().
** exception error: undefined function dist_util:gen_challenge/0

5> application:set_env(stdlib, shell_debug_unexported, true).
ok

6> dist_util:gen_challenge().
558236439
```

Calling Non-Exported Functions

Executing interpreted code from embedded debug_info

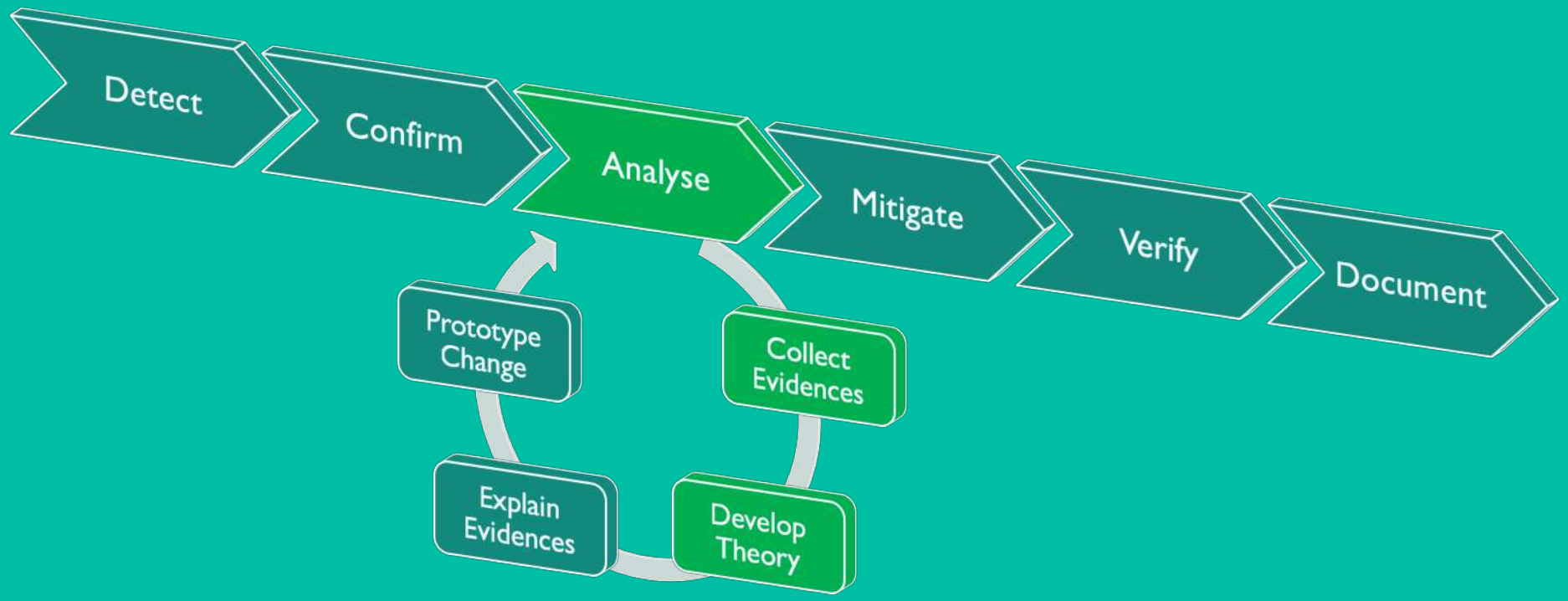



```
 {function,166,handshake_other_started,1,
           [{clause,166,[{match,...}],[],[...]},
            {clause,198,[{...}],[...],...}]},
 {function,202,log_disallowed_node_attempt,1,
           [{clause,202,[{...}],[],...}]},
 {function,213,check_dflags,2,[{clause,213,[...],...}]},

< ... >

 {function,458,gen_challenge,0,
           [{clause,458,[],[],
                    [{match,459,
                            {var,459,'A'
```

Workflow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Realtime Monitoring Data

High resolution metrics to confirm an ongoing issue

```
washared528    | ERL   msg------------ dist--------- wan----------  sched mem---
time           | nodes qlen qmax  recv  msgin msgout  wanin wanout  %util tot Mb
01/24 20:39:10   1200    0    0 37043   2623   2631   4525  10074   92.3  21328
01/24 20:39:11   1200    1    1 40571   2734   2699   4620  10600   92.7  21305
01/24 20:39:12   1200    1    1 56928   2582   2678   5507  12572   95.7  21316
```

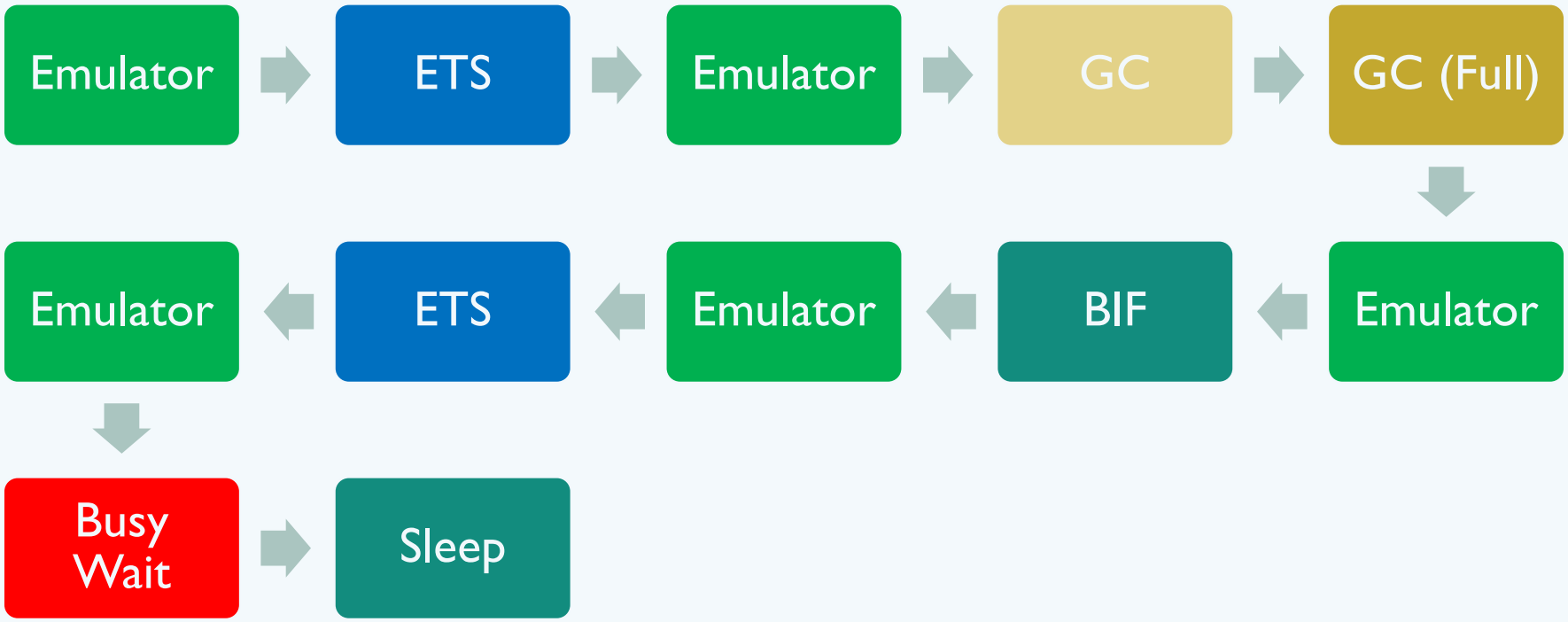
Resource Classes

CPU, memory, network

- Normal schedulers (emulator threads)
- Dirty CPU schedulers
- Dirty I/O schedulers
- I/O polling thread(s)
- Auxiliary threads

Scheduler Is New CPU Core

Life of a perfectly normal scheduler



Microstate Accounting

With some CPU to spare

Thread	alloc	bif	emulator	ets	gc	nif	sleep
Stats per type:							
async	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
aux	0.15%	0.00%	0.00%	0.00%	0.00%	0.00%	98.12%
dirty_cpu_sche	0.13%	0.00%	0.00%	0.00%	0.34%	0.00%	99.38%
dirty_io_sched	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
poll	0.07%	0.00%	0.00%	0.00%	0.00%	0.00%	99.27%
scheduler	**6.06%**	**10.14%**	**29.70%**	**9.00%**	**3.42%**	**5.94%**	**23.17%**

Microstate Accounting

ETS lock contention

Thread	alloc	bif	emulator	ets	gc	nif	sleep
dirty_cpu_sche	4.13%	0.00%	0.00%	0.00%	0.34%	0.00%	99.38%
scheduler	0.41%	0.82%	4.11%	82.02%	1.01%	1.01%	7.11%

Microstate Accounting

Misbehaving NIFs (possible lock contention)

Thread	alloc	bif	emulator	ets	gc	nif	sleep
dirty_cpu_sche	4.13%	0.00%	0.00%	0.00%	0.34%	0.00%	99.38%
scheduler	2.66%	2.14%	10.11%	2.02%	1.01%	78.94%	2.81%

Microstate Accounting

Too much garbage produced

Thread	alloc	bif	emulator	ets	gc_full	nif	sleep
dirty_cpu_sche	7.13%	0.00%	0.00%	0.00%	82.61%	0.00%	10.71%
scheduler	5.96%	11.04%	19.50%	9.00%	0.42%	5.94%	45.17%

Memory

RAM consumption – inspired by recon library by Fred Hebert

- Allocators statistics
- Memory leaks analysis
- Supervision tree aggregates

Allocation Statistics

Readily available via ectl framework

```
dev1214.atn /home/whatsapp# ectl erl_alloc
=================================================================================
Allocator       % util   Allocated       Used       Free     Blocks   Avg Size  Strategy
=================================================================================
temp_alloc        0.00      4.13MB         0B      4.13MB          0          -     gf,af
sl_alloc          0.05      1.03MB       592B      1.03MB          7         84B   aoffcbf
std_alloc         5.87     67.03MB      3.94MB     63.10MB      20823        198B   aoffcbf
ll_alloc         34.95    196.50MB     68.67MB    127.83MB      73507        979B   aoffcbf
eheap_alloc      44.56      1.22GB    555.28MB    690.84MB      24444     23.26KB   aoffcbf
ets_alloc        17.59      18.38GB     3.23GB     15.15GB   21004902        165B   aoffcbf
fix_alloc        18.89     65.03MB     12.29MB     52.75MB      62698        205B   aoffcbf
literal_alloc    80.23      4.00MB      3.21MB    809.65KB        300     10.95KB      aobf
binary_alloc     49.99      1.10GB    565.45MB    565.58MB     137795      4.20KB   aoffcbf
driver_alloc     15.01     65.03MB      9.76MB     55.27MB      16157        633B   aoffcbf
=================================================================================
```

Allocation Statistics

Changed allocation strategy

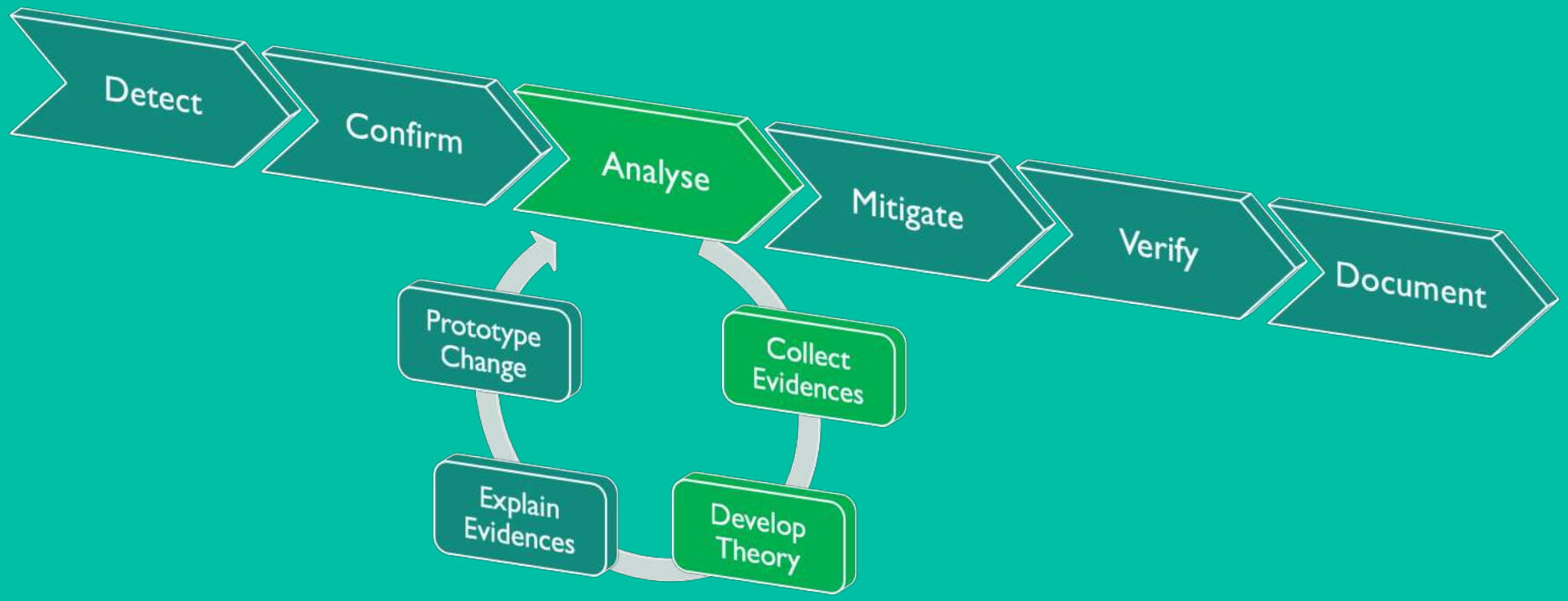
```
dev1214.atn /home/whatsapp# ectl erl_alloc
=================================================================================
Allocator       % util   Allocated       Used       Free     Blocks   Avg Size  Strategy
=================================================================================
temp_alloc        0.00      4.13MB         0B      4.13MB          0          -     gf,af
sl_alloc          0.02      1.03MB       200B      1.03MB          2       100B   aoffcbf
std_alloc         5.30     67.03MB      3.55MB     63.48MB      20727       179B   aoffcbf
ll_alloc         50.04    136.50MB     68.30MB     68.20MB      72750       984B   aoffcbf
eheap_alloc      50.33      1.03GB    532.54MB    525.59MB      24208    22.53KB   aoffcbf
ets_alloc        72.79      3.09GB      2.25GB    862.42MB   16335118       148B      aobf
fix_alloc        18.58     65.03MB     12.08MB     52.95MB      60052       210B   aoffcbf
literal_alloc    79.17      4.00MB      3.17MB    853.28KB        287    11.30KB      aobf
binary_alloc     45.94      1.07GB    503.09MB    591.94MB     132180     3.90KB   aoffcbf
driver_alloc     18.23     65.03MB     11.86MB     53.18MB      28038       443B   aoffcbf
=================================================================================
```

Memory Leaks Analysis

Forcing garbage collection to detect dirty processes

```
dev1214.atn /home/whatsapp# ectl erl_leaks
=================================================================================================
Pid            Name          binary_refs            binary_size    binary_count              heap_size
=================================================================================================
<0.6410.0>    <...>    1392547 (1392547)    230.61MB (230.61MB)     1264 (1264)    224.14KB (211.66KB)
<0.3424.6>    <...>      700592 (700591)    163.29MB (163.29MB)      860 (859)    362.67KB (277.06KB)
<0.5564.0>    <...>      107753 (107753)    155.94MB (155.94MB)      444 (444)    586.82KB (574.34KB)
<0.175.0>    wa_wan      284156 (284156)    126.50MB (126.50MB)      588 (588)     85.61KB (73.13KB)
<0.54.0>    inet_db      175151 (175150)    123.72MB (123.72MB)      913 (912)    586.82KB (501.21KB)
<0.23406.5>   <...>      950628 (950628)    114.72MB (114.72MB)      978 (978)    224.14KB (216.43KB)
<0.23438.5>   <...>      345748 (345748)     69.19MB (69.19MB)       592 (592)    224.14KB (216.43KB)
<0.3482.6>    <...>              152 (0)          56.50MB (0B)          8 (0)     12.48KB (-20696B)
<0.70.0>        pg2               45 (0)          54.27MB (0B)          5 (0)     12.48KB (-20696B)
<0.340.0> wa_shell                43 (0)          54.27MB (0B)          5 (0)     12.48KB (-20696B)
=================================================================================================
```

Workflow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gdb: Open Heart Surgery

Non-stop mode + background execution

```
(gdb) file /usr/lib64/erlang/erts-10.2/bin/beam.smp
(gdb) source /usr/lib64/erlang/etc/etp-commands
(gdb) set target-async 1
(gdb) set pagination off
(gdb) set non-stop on
(gdb) attach 97806 &
```

etp-commands

BEAM is able to survive short interruptions

```
(gdb) thread 73
(gdb) interrupt 73
(gdb) etp-schedulers
--- Scheduler 1 ---
 IX: 0
 CPU Binding: 0
  - Run Queue -
  Length: total=1123, max=0, high=0, normal=1122,
low=1, port=0
```

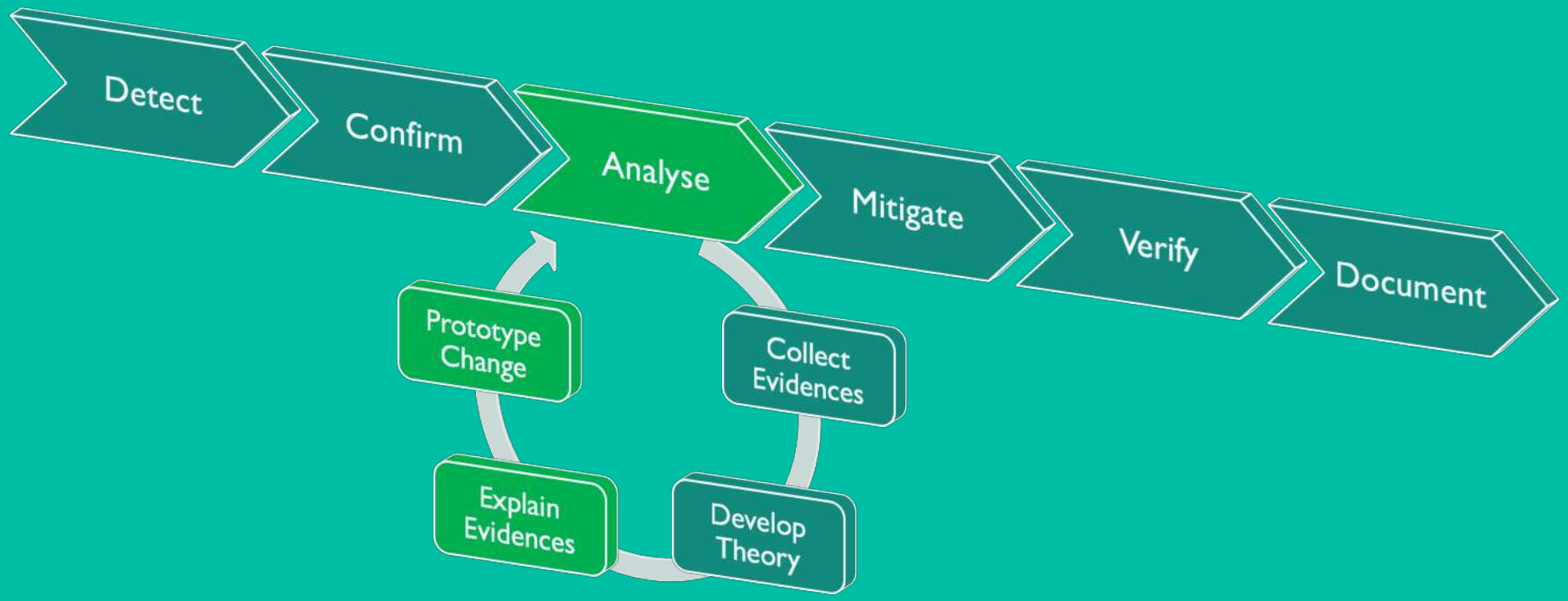
Hack The Source

```
            for (i=nlocks-1; i>=0; --i) {
-               lock_vec[i] = enif_rwlock_create("crypto_stat");
+               snprintf(lock_name, sizeof(lock_name), "crypto_%s", CRYPTO_get_lock_name(i));
+               lock_vec[i] = enif_rwlock_create(lock_name);
                if (lock_vec[i]==NULL) return NULL;
```

Meaningful lock name

```
(chatd@cdev0015.frc)3> lcnt:conflicts().
            lock    id   #tries  #collisions  collisions [%]  time [us]  duration [%]
           -----   ---  ------- ------------ --------------- ---------- -------------
      crypto_rsa     1   280851       190678         67.8929  899670045      617.4626
         db_tab  9282 13009375       132871          1.0213    5075031        3.4831
      run_queue    34 51182832       771052          1.5065     987565        0.6778
```

Workflow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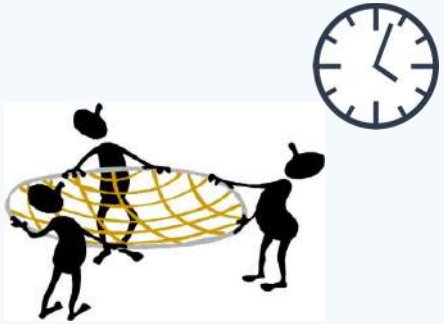
Prototyping In Production

Trying a change in production – fastest turnaround time

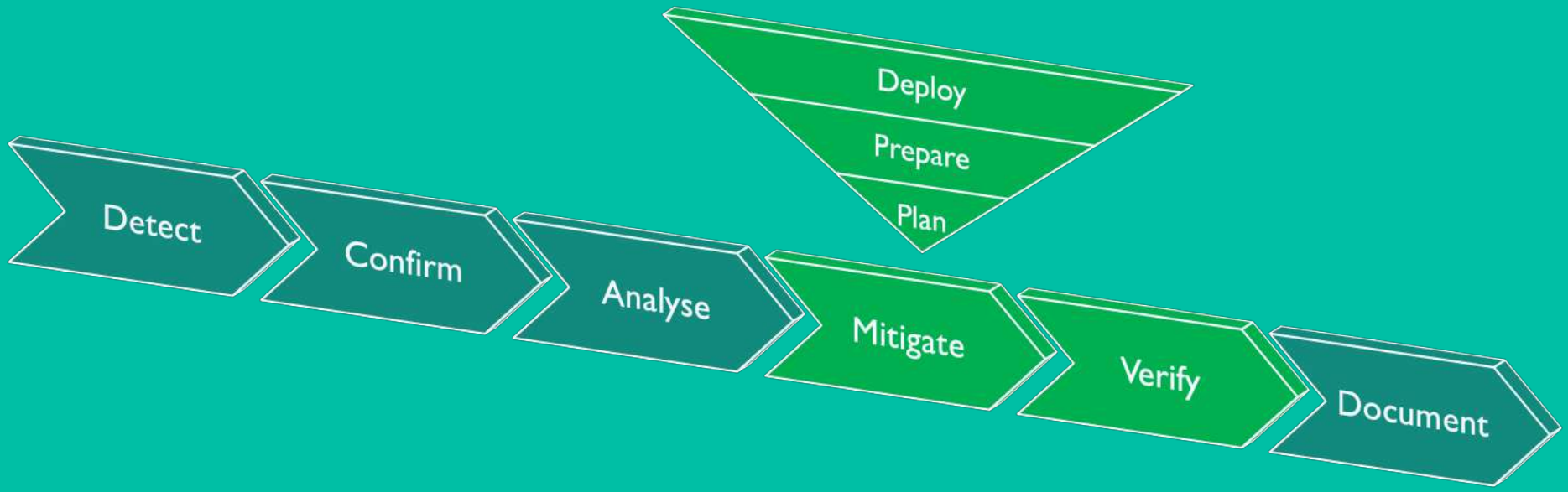
- Toolchain is installed on every production node
- Using code hot-load
- Immediate effect – for good or bad
- Does not replace testing

Reliability Layer: Peace of Mind

Messaging service is a closed loop



Workflow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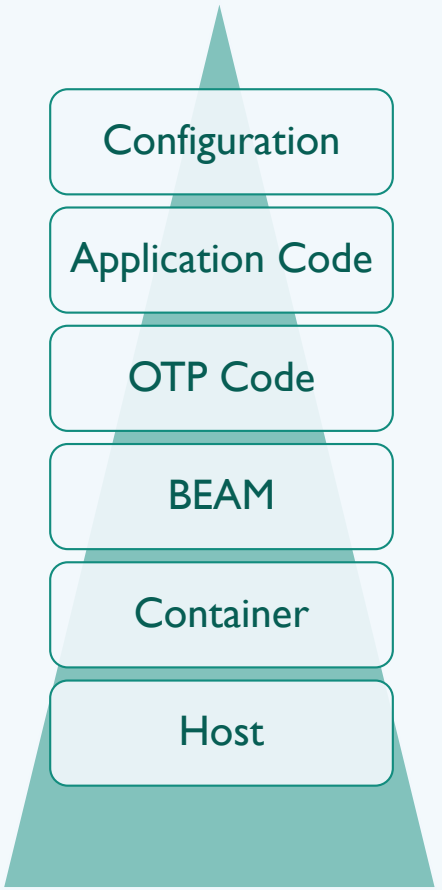
Plan, Prepare, Deploy

Plan always comes first

- Define change level
- Announce/notify interested parties
- Execute mitigation plan
- Test the whole stack:
  - hot code load/live update
  - restart of an underlying layer

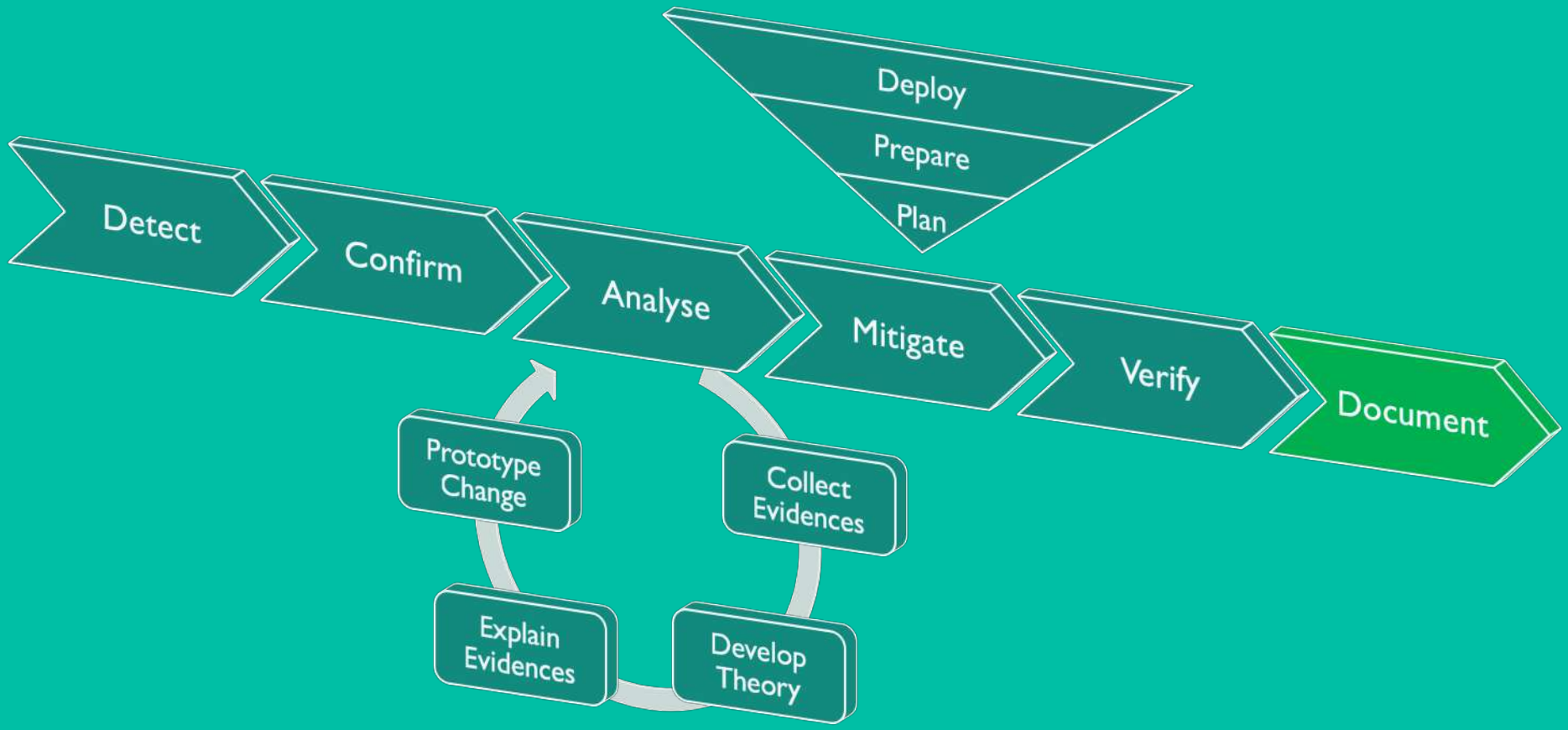


Slow Roll

Keep failover option as long as possible

- Deploy to a single node
- Deploy to a range of nodes in a single DC
- [Optional] Deploy to a range of nodes in multiple DCs
- Deploy to a single DC
- Full-scale deployment

Workflow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Test Case As Documentation

It's better if it's automated

- Stays up to date
- Serves as a contract (interface and use cases)
- Catches regressions
- Not always possible
- Not always feasible
- Does not replace **monitoring and evidence collection**!

Questions?

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