

# BANO node software development kit

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# 1 Overview

This documents the BANO node software development kit, including the build environment and programming interface. It is primarily intended for node developers.

## 1.1 Installing SDK and dependencies

The BANO SDK depends on the AVR GNU toolchain being installed on the system and accessible using the PATH environment variable. On a LINUX DEBIAN system, this toolchain is installed using:

```
$> aptitude install gcc-avr
```

Also, the AVRDUDE tool is used to upload the binary file in the device flash:

```
$> aptitude install avrdude
```

Note that this tools are shipped with the ARDUINO environment.

Retrieving the BANO SDK requires cloning 3 repositories:

- the BANO SDK itself, which contains all the files required to develop node and a base applications,
- the NRF SDK, which provides support for NRF905 and NRF24L01P wireless chipsets from Nordic Semiconductor,
- the AVR CRYPTO library, which is used for message encryption.

It is recommended to install them at the same level:

```
$> cd ~/repo
$> git clone https://github.com/texane/bano.git
$> git clone https://github.com/texane/nrf.git
# only for message encryption
$> mkdir ~/repo/crypto-lib
$> cd ~/repo/crypto-lib
$> svn co http://das-labor.org/svn/microcontroller-2/crypto-lib .
```

Also, a node example can be retrieved, built and uploaded using:

```
$> git clone https://github.com/texane/bano_led.git
$> cd bano_led
$> BANO_DIR=~/repo/bano make
$> BANO_DIR=~/repo/bano make upload
```

## 2 Build environment

### 2.1 Makefile variables

BANO allows the developer to interact with the build system by defining or overriding default variables in the node makefile:

- **BANO\_DIR**: the BANO top directory. If the previous section instructions were followed, the **BANO\_DIR** variable would be set to `$(HOME)/repo/bano`. This variable is mandatory,
- **NRF\_DIR**: the NRF top directory. default to `$(BANO_DIR)/../nrf`,
- **CRYPTOLIB\_DIR**: the CRYPTO-LIB top directory. default to `$(BANO_DIR)/../cryptolib`,
- **BANO\_BOARD**: the node board. Currently, only `minipro_3v3` is supported. This variable is mandatory,
- **NRF\_DIR**: the NRF top directory. By default, the SDK assumes that the NRF directory is located in the BANO parent directory, as recommended in the previous section,
- **BANO\_C\_FILES**: the list of C source files. This list can not be empty,
- **BANO\_S\_FILES**: an optional list of assembler source files. Names must end with big S suffixes (ie. `main.S`). GCC is used as the assembler allowing preprocessor directives. This list can be empty,
- **BANO\_NODL\_ID**: the NODL identifier as an hexadecimal 32 bits unsigned integer. If not defined, 0 is used,
- **BANO\_NODE\_ADDR**: the node address as an hexadecimal 32 bits unsigned integer. If not defined, a random value is generated by the build system,
- **BANO\_NODE\_SEED**: the node seed as an hexadecimal 32 bits unsigned integer. If not defined, a random value is generated by the build system,
- **BANO\_CIPHER\_ALG**: if defined, the 128 bits block cipher algorithm to use. Currently supported are: `none`, `xtea` and `aes`,
- **BANO\_CIPHER\_KEY**: if **BANO\_CIPHER\_ALG** is defined, this variable contains the key used to encrypt and decrypt messages. It is represented as a comma separated string of 16 8 bits unsigned integers in hexadecimal. If not defined, a random value is generated by the build system.

### 2.2 Makefile rules

The makefile provides the following rules:

- **all**: also the default rule. It produces the final image that can then be uploaded,
- **upload**: upload to the board,
- **clean**: clean all the temporary files.

## 2.3 Example makefile

```
# node built for the arduino minipro 3.3v board
# it assumes that BANO_DIR is defined by the environment
# it consists of a single C file main.c
# the node address is statically defined

BANO_DIR := $(HOME)/repo/bano
BANO_BOARD := minipro_3v3
BANO_NODE_ADDR := 0x5c5f8548
BANO_C_FILES := main.c

include $(BANO_DIR)/build/node/top.mk
```

## 3 Programming reference

### 3.1 Overview

BANO offers a runtime and the corresponding programming interface that abstracts a node application logic from low level details such as hardware architecture and protocol implementation. The interface is mainly descriptive and event based: the developer first initializes node related information. The BANO runtime then calls application handlers whenever appropriate: network messages reception, timers, hardware related interrupts ...

### 3.2 Files

node/bano\_node.h: function and type declarations.

### 3.3 Types

```
typedef struct
{
    /* 100 milliseconds units, max 10736 */
    uint16_t timer_100ms;

    /* waking event mask */
#define BANO_WAKE_NONE 0
#define BANO_WAKE_TIMER (1 << 0)
#define BANO_WAKE_MSG (1 << 1)
#define BANO_WAKE_POLL (1 << 2)
#define BANO_WAKE_PCINT (1 << 3)
    uint8_t wake_mask;

    /* module disabling mask */
#define BANO_DISABLE_ADC (1 << 0)
#define BANO_DISABLE_WDT (1 << 1)
#define BANO_DISABLE_CMP (1 << 2)
#define BANO_DISABLE_USART (1 << 3)
#define BANO_DISABLE_NONE 0x00
#define BANO_DISABLE_ALL 0xff
    uint8_t disable_mask;

    uint32_t pcint_mask;
} bano_info_t;

static const bano_info_t bano_info_default =
{
    .wake_mask = BANO_WAKE_NONE,
    .disable_mask = BANO_DISABLE_ALL
};
```

### 3.4 Functions

```
/* exported by the runtime */
uint8_t bano_init(const bano_info_t*);
uint8_t bano_fini(void);
uint8_t bano_send_set(uint16_t, uint32_t);
uint8_t bano_wait_event(bano_msg_t*);
uint8_t bano_loop(void);

/* implemented by the application */
extern uint8_t bano_set_handler(uint16_t, uint32_t);
extern uint8_t bano_get_handler(uint16_t, uint32_t*);
extern uint8_t bano_timer_handler(void);
extern uint8_t bano_pcint_handler(void);
```

## 4 Examples

### 4.1 Enable/disable a LED on BANO messages

```
#include <stdint.h>
#include <avr/io.h>
#include "bano/src/node/bano_node.h"

/* led routines */

#define LED_DDR DDRB
#define LED_PORT PORTB
#define LED_MASK (1 << 1)

static void led_set_high(void)
{
    LED_DDR |= LED_MASK;
    LED_PORT |= LED_MASK;
}

static void led_set_low(void)
{
    LED_DDR |= LED_MASK;
    LED_PORT &= ~LED_MASK;
}

/* event handlers */

#define LED_KEY 0x0000

static uint8_t led_value = 0;

uint8_t bano_get_handler(uint16_t key, uint32_t* val)
{
    /* called by the runtime on GET messages */

    if (key != LED_KEY) return (uint8_t)-1;
    *val = led_value;
    return 0;
}

uint8_t bano_set_handler(uint16_t key, uint32_t val)
{
    /* called by the runtime on SET messages */

    if (key != LED_KEY) return (uint8_t)-1;
    led_value = val;
    if (led_value == 0) led_set_low();
    else led_set_high();
    return 0;
}

/* unused */
uint8_t bano_pcount_handler(void) { return (uint8_t)-1; }
uint8_t bano_timer_handler(void) { return (uint8_t)-1; }

int main(void)
{
    /* initialize the runtime and loop forever */

    bano_info_t info;

    info = bano_info_default;
    info.wake_mask |= BANO_WAKE_MSG;
    bano_init(&info);

    bano_loop();

    bano_fini();

    return 0;
}
```

## 4.2 Send periodic messages

```
#include <stdint.h>
#include <avr/io.h>
#include "bano/src/node/bano_node.h"

uint8_t bano_timer_handler(void)
{
    /* called every 10 seconds */

    bano_send_set(0x002a, 0xdeadbeef);
    return 0;
}

/* unused */
uint8_t bano_get_handler(uint16_t key, uint32_t* val) { return (uint8_t)-1; }
uint8_t bano_set_handler(uint16_t key, uint32_t val) { return (uint8_t)-1; }
uint8_t bano_pcnt_handler(void) { return (uint8_t)-1; }

int main(void)
{
    bano_info_t info;

    info = bano_info_default;

    info.wake_mask |= BANO_WAKE_TIMER;
    info.timer_100ms = 100;

    bano_init(&info);

    bano_loop();

    bano_fini();

    return 0;
}
```

## 4.3 Send message when GPIO changes

```
#include <stdint.h>
#include <avr/io.h>
#include "bano/src/node/bano_node.h"

#define GPIO_KEY 0x0000

#define GPIO_DDR DDRD
#define GPIO_PIN PIND
#define GPIO_MASK (1 << 3)

uint8_t bano_pcint_handler(void)
{
    bano_send_set(GPIO_KEY, GPIO_PIN & GPIO_MASK);
    return 0;
}

/* unused */
uint8_t bano_get_handler(uint16_t key, uint32_t* val) { return (uint8_t)-1; }
uint8_t bano_set_handler(uint16_t key, uint32_t val) { return (uint8_t)-1; }
uint8_t bano_timer_handler(void) { return (uint8_t)-1; }

int main(void)
{
    bano_info_t info;

    info = bano_info_default;

    info.wake_mask |= BANO_WAKE_PCINT;
    info.pcint_mask = 1UL << 19UL;
    bano_init(&info);

    bano_loop();

    bano_fini();

    return 0;
}
```