# Introducing Man In The Contacts attack to trick encrypted messaging apps

Bsides Lisbon

11/11/2016 – Securing Apps

# whois securingapps

- Developer background
- French who spent last 10 years working in Switzerland on security products and solutions
  - Focus on mobile since 2010
- Now software security consultant at my own company

http://www.securingapps.com

- Provide services to build security in software
  - Mobile
  - Web
  - Cloud
  - Internet Of Things
  - Bitcoin/Blockchain

@SecuringApps

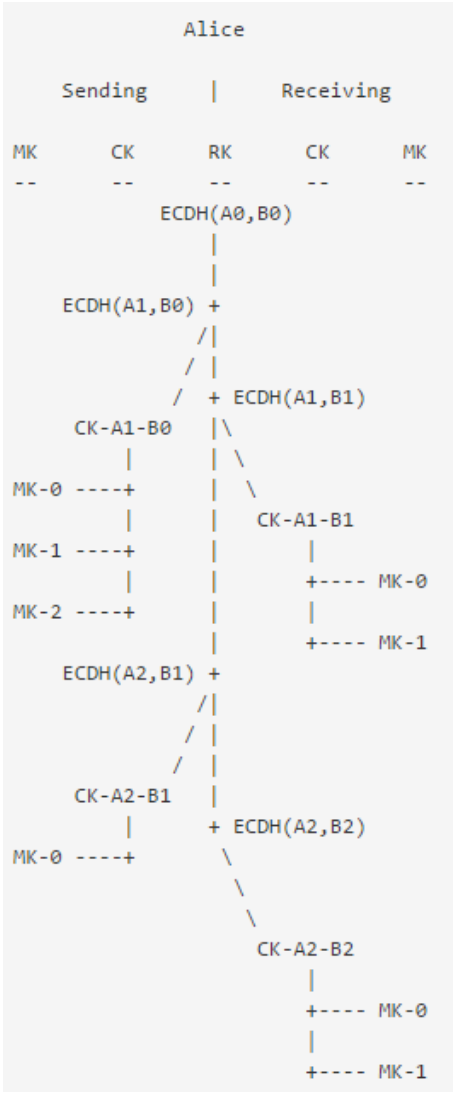
# Introduction

- Popular messaging apps recently switched to End-to-End encryption
  - Great communication around it
  - Privacy now is a requirement
- Debates at the government level to ask for backdoors
  - Going dark ?
  - Used by terrorists ?
- Increased feeling that those applications are unbreakable

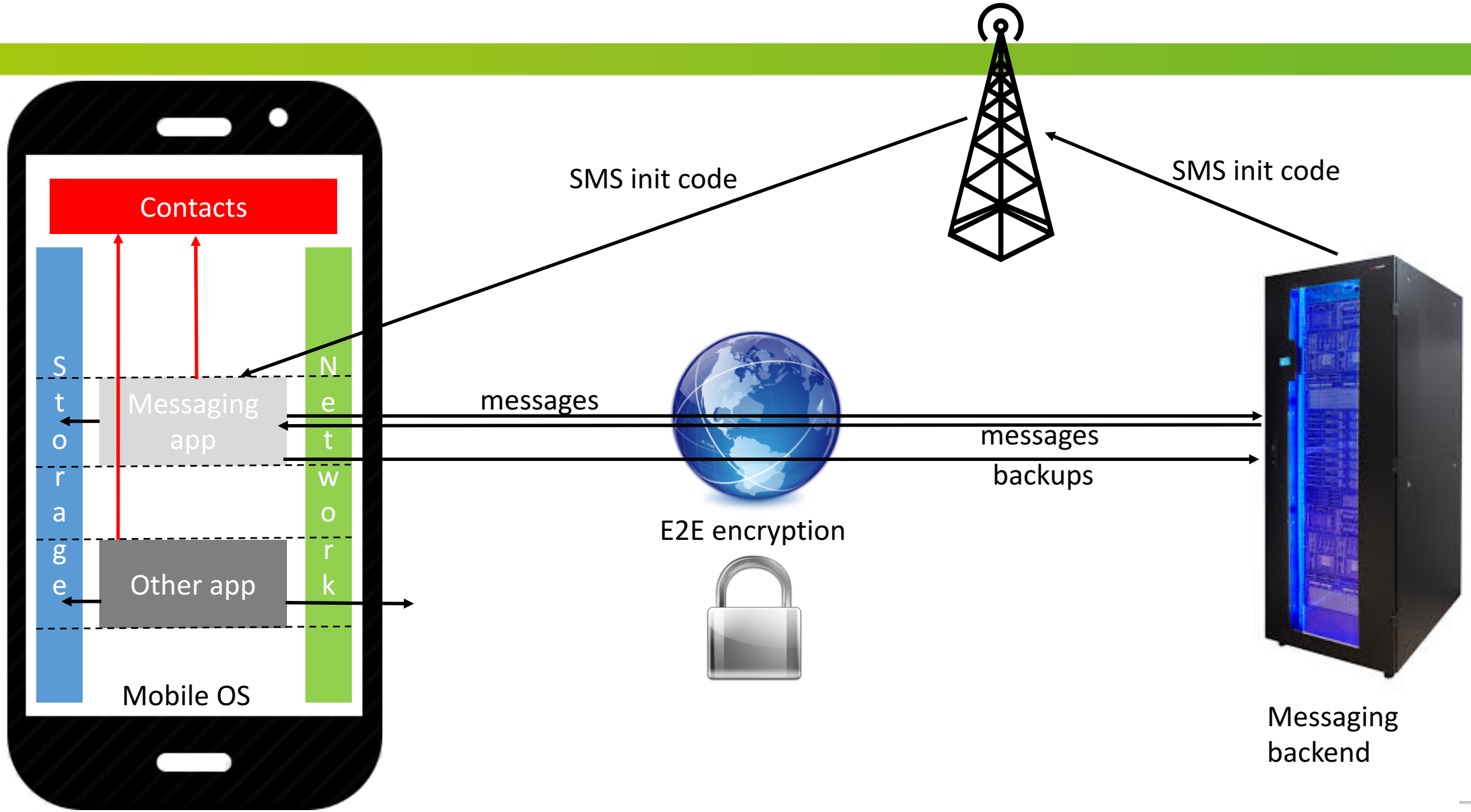
# Super crypto. But wait ….

- Advanced ratcheting in Signal Protocol →
- Looks like an obvious flaw won't be there

- But how messaging apps authenticate myself ?
  - No explicit identifier
  - Provisioning done via SMS
  - Link to device/phone number
  - And when I change phone number ?
- And my contacts ?
  - Get them from my address book
  - No manual contact handling (e.g. Skype)



# Threat model: mobile focus & simplified



# Accessing contacts

- Easy to read/modify/create contacts
  - There is an API for that
  - Android example

```
private boolean updateContactName(String phone, String newName) {
    ArrayList<ContentProviderOperation> ops = new ArrayList<ContentProviderOperation>();

    ops.add(ContentProviderOperation.newUpdate(ContactsContract.Data.CONTENT_URI)
            .withSelection(ContactsContract.CommonDataKinds.Phone.NUMBER + "=?", new String[]{String.valueOf(phone)})
            .withValue(ContactsContract.CommonDataKinds.StructuredName.DISPLAY_NAME, newName)
            .build());
    try {
        getContentResolver().applyBatch(ContactsContract.AUTHORITY, ops);
        return true;
    } catch (Exception e) {
        Log.e("oups","aie",e);
    }
    return false;
}
```

- Shared data structure accessible in read/write
  - Only restricted by permissions
  - And it contains authentication data in clear !

```
<uses-permission android:name="android.permission.READ_CONTACTS" />
<uses-permission android:name="android.permission.WRITE_CONTACTS" />
```

- There is **room for a side channel attack: Man In The Contacts**
  - Not requiring a rooted device (e.g no RowHammer attack)

# Introducing Alice, Bob and Eve

- Convention: Alice on the left, Bob on the right, Eve in the center
- **Devices not rooted**, latest OS updates available
- Installed apps: latest version (29th October 2016) of **WhatsApp**, **Telegram** and **Signal**

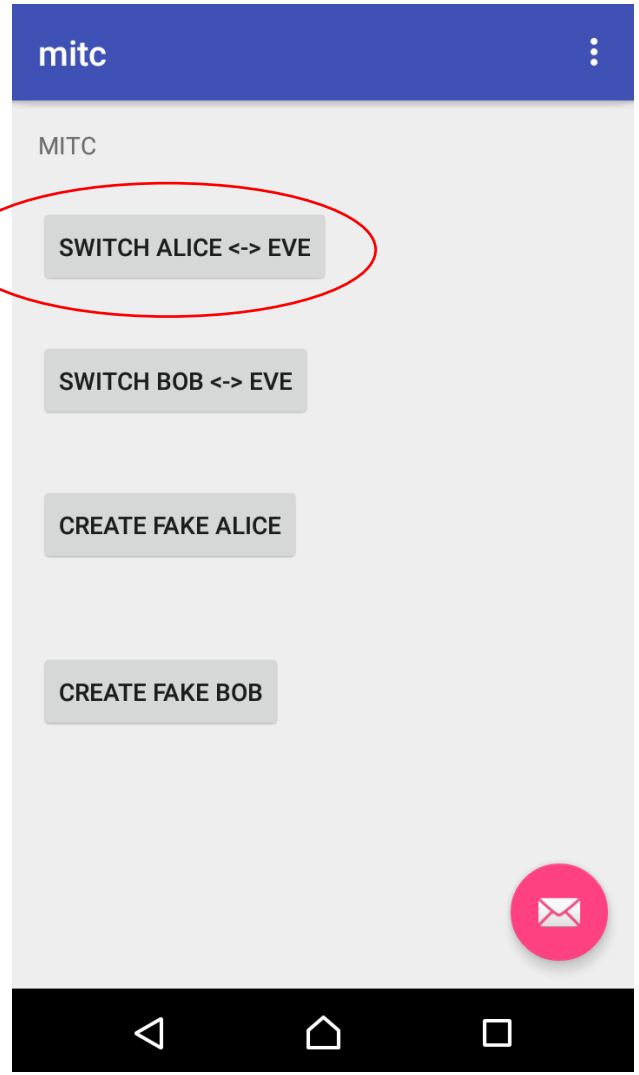

Alice
+33 X XX XX XX 60
Android 5.0

Eve
+41 XX XXX XX 21
iOs 10.1

Bob
+41 XX XXX XX 66
Android 5.1

# Old joke: swap contacts

- Install MITC app on Bob's device
- Start a conversation between Alice and Bob
- Swap Alice and Eve phone numbers on Bob's device
- See what happens




Bob

# Old joke: swap contacts

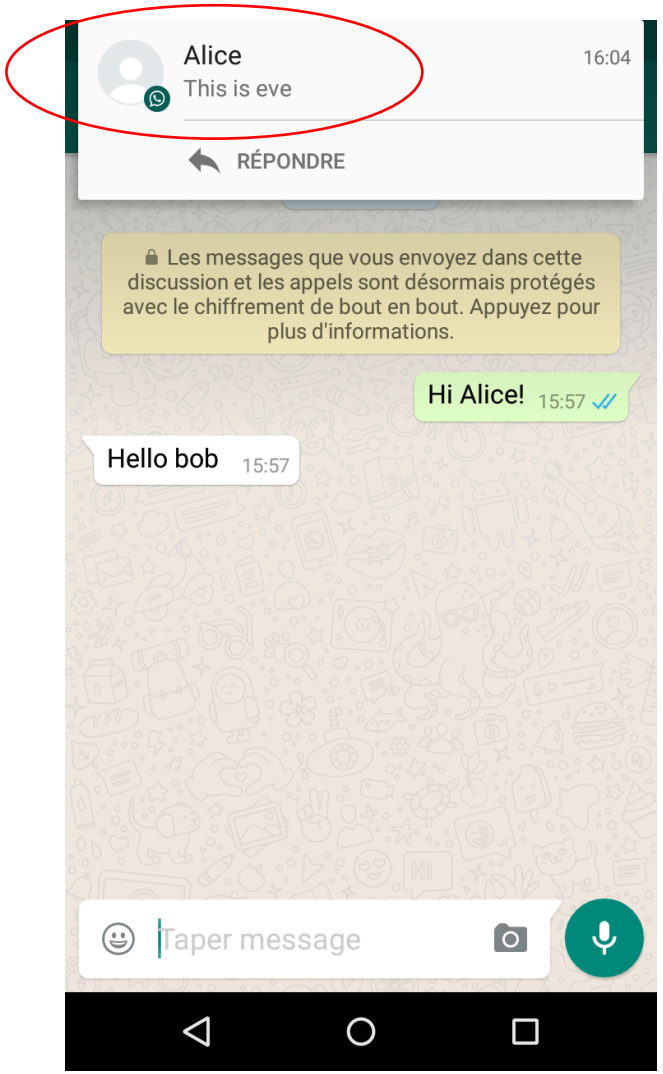
- WhatsApp 1

- Bob starts a conversion with Alice
- Alice answers


Bob

# Old joke: swap contacts

- WhatsApp 2
- Eve triggers contact swap via remote MITC app on Bob's device
- Eve sends «This is eve» to Bob
- Notification received as Alice
- But new conversation




Bob

# Old joke: swap contacts

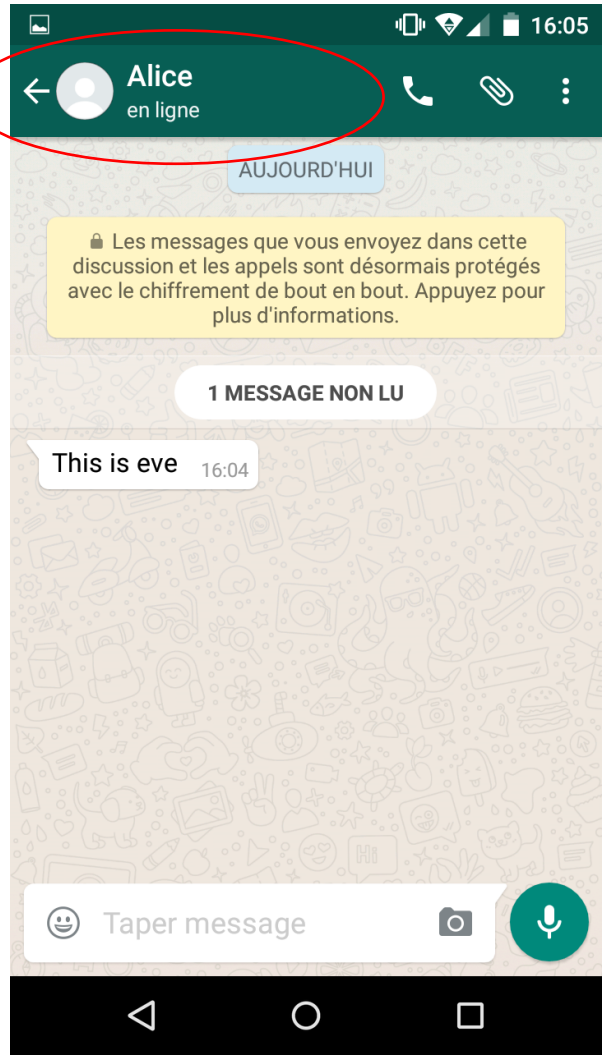
- WhatsApp 3
- Ignore notification
- Conversation of Alice now displayed as Eve


Bob

# Old joke: swap contacts

- WhatsApp 4

- Accept notification
- Eve triggered a new conversation
- But displayed as Alice

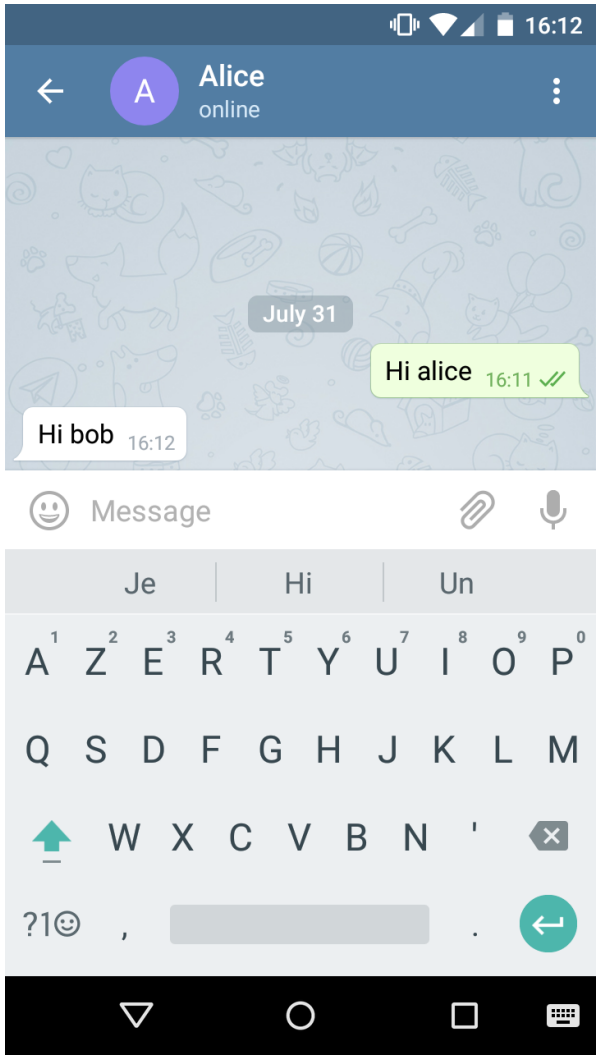



Bob

# Old joke: swap contacts

- Telegram 1

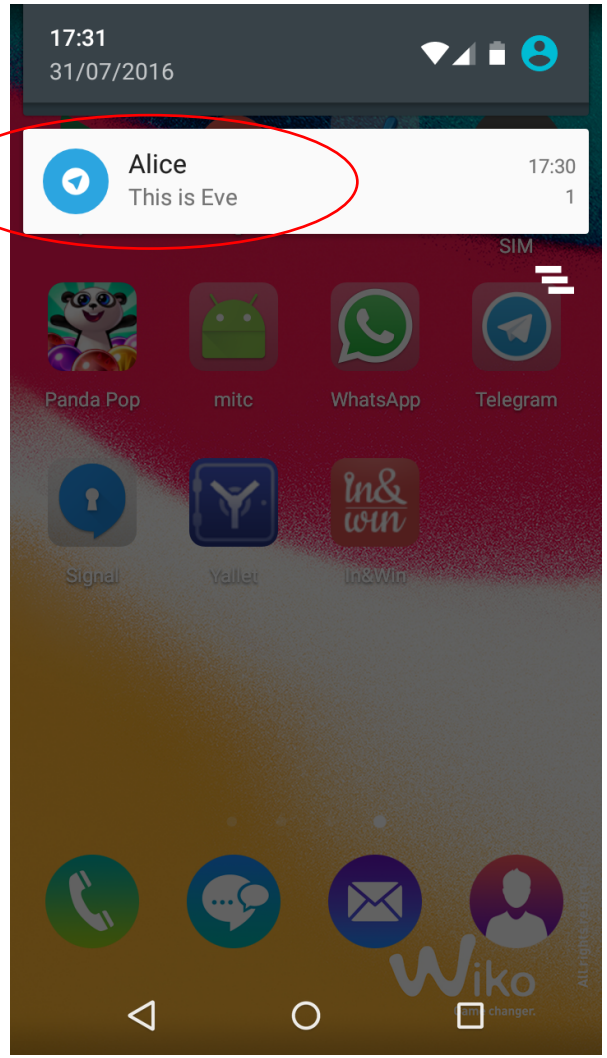
- Bob starts a conversion with Alice
- Alice answers




Bob

# Old joke: swap contacts

- Telegram 2
- Eve triggers contact swap via remote MITC app on Bob's device
- Eve sends «This is Eve» to Bob
- Notification received as Alice
- But new conversation



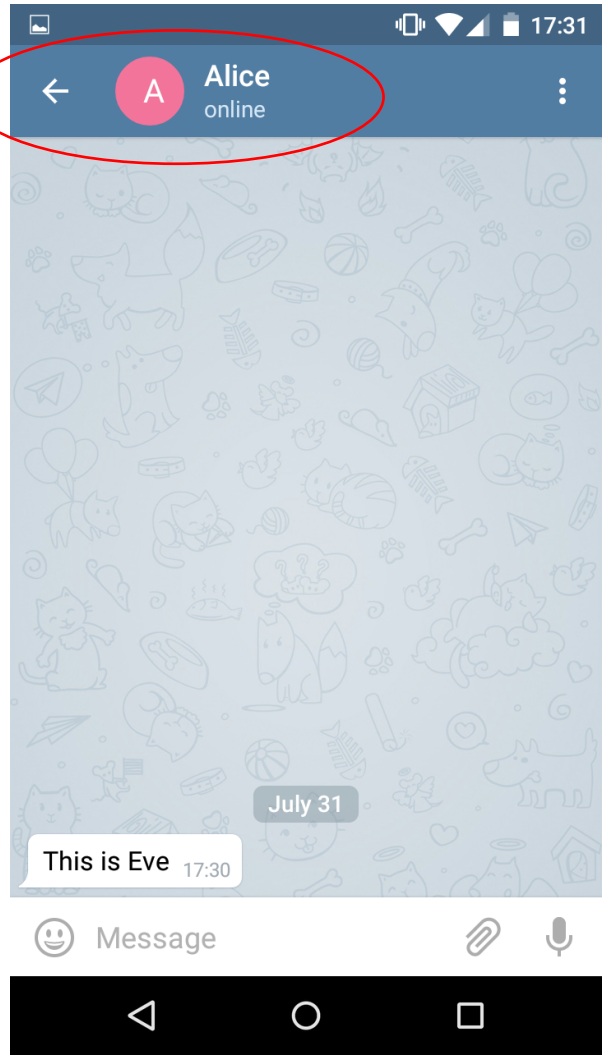

Bob

# Old joke: swap contacts

- Telegram 3

- Accept notification
- Eve triggered a new conversation
- But displayed as Alice

- NB: If you change the name of Alice, in the future notifications and conversations will still be under the name of Alice

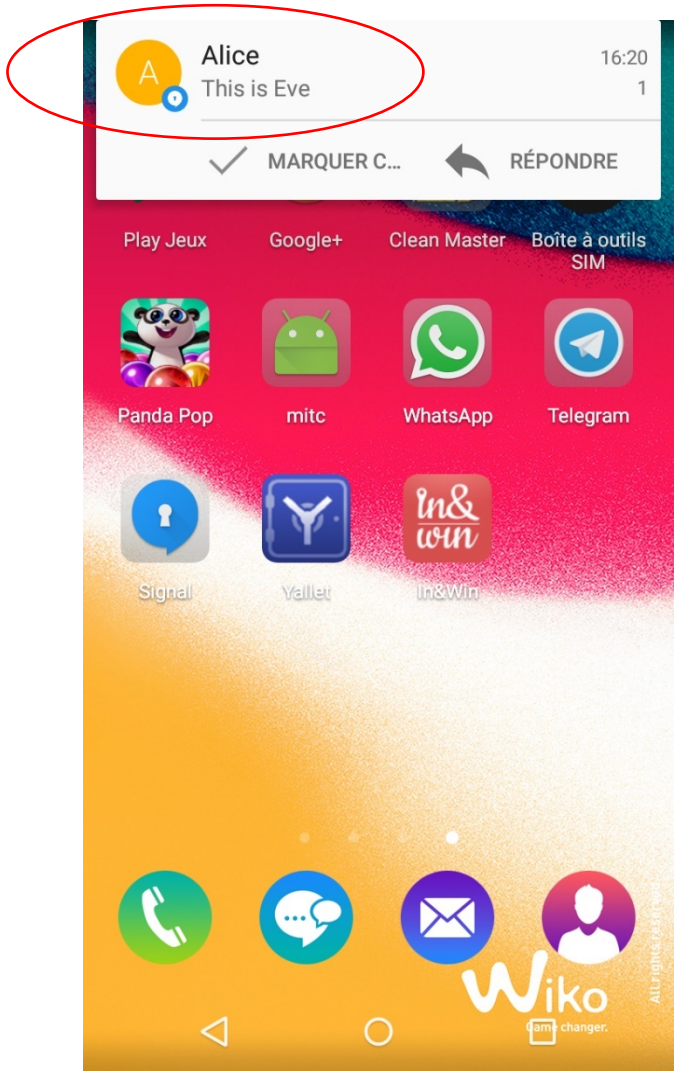



Bob

# Old joke: swap contacts

- Signal 1 & 2

- Screenshots refused by Android app
- But same behaviour than WhatsApp

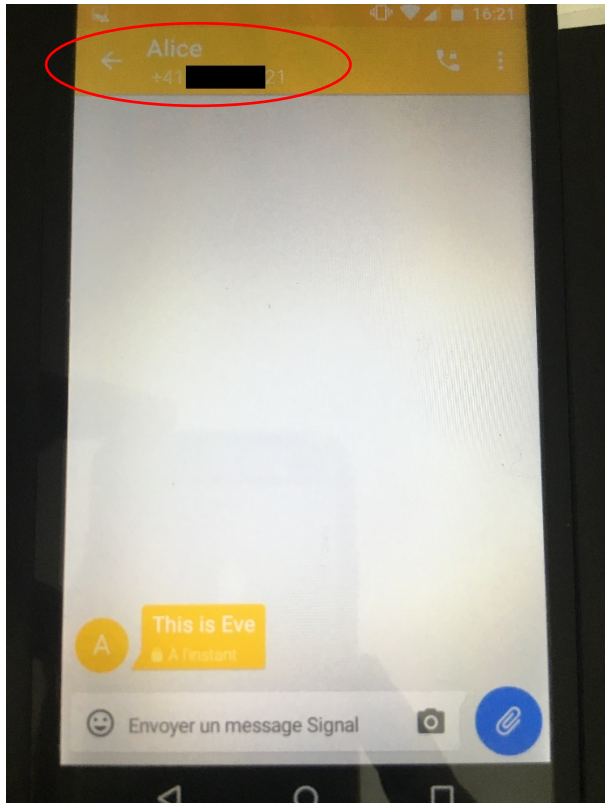



Bob

# Old joke: swap contacts

- Signal 3

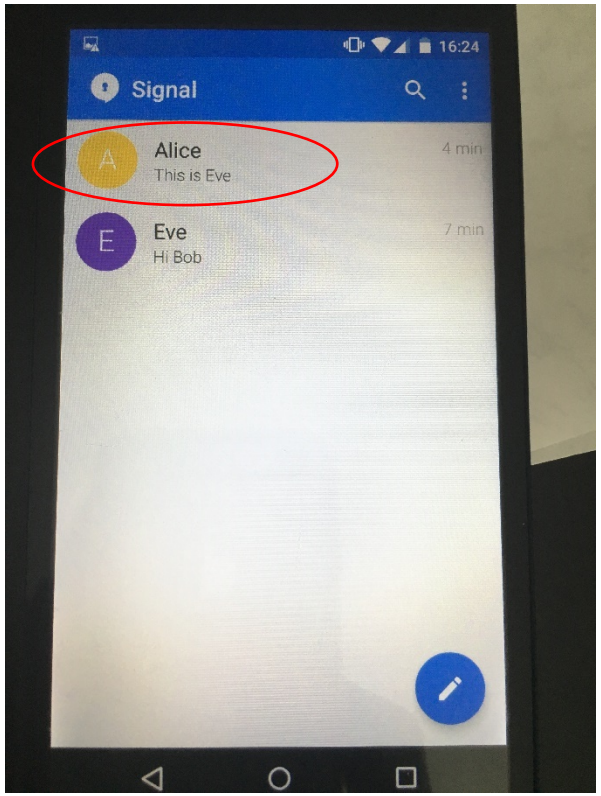
- Accept notification
- Eve triggered a new conversation
- Displayed as Alice
- But phone number also displayed (the iOs version doesn't display it)




Bob

# Old joke: swap contacts

- Signal 4
- Not the case in the main view

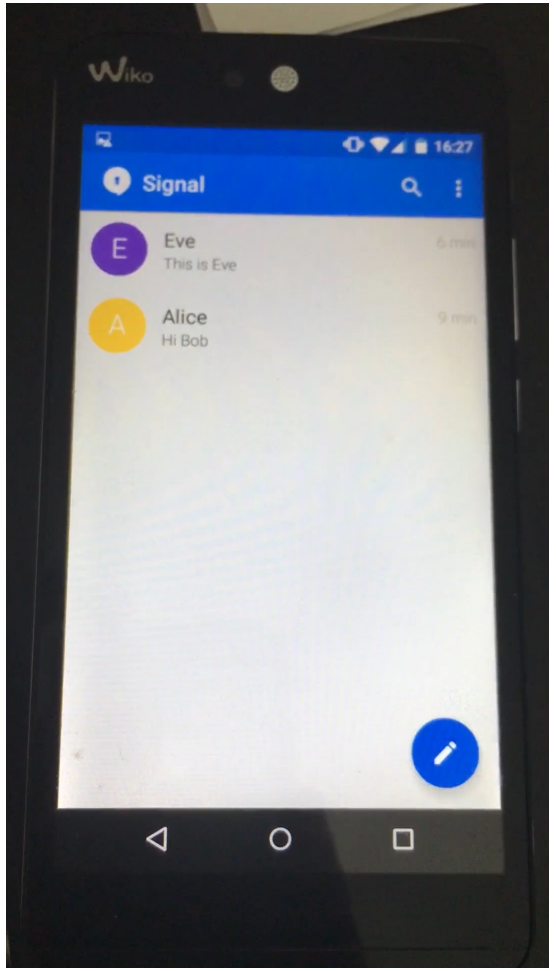



Bob

# Old joke: swap contacts

- Signal 5

- Stay in this view
- Switch back contacts with MITC app
- Nothing happens for a while
- And then main view updated
  => contact sync process




Bob

# Swap contacts results

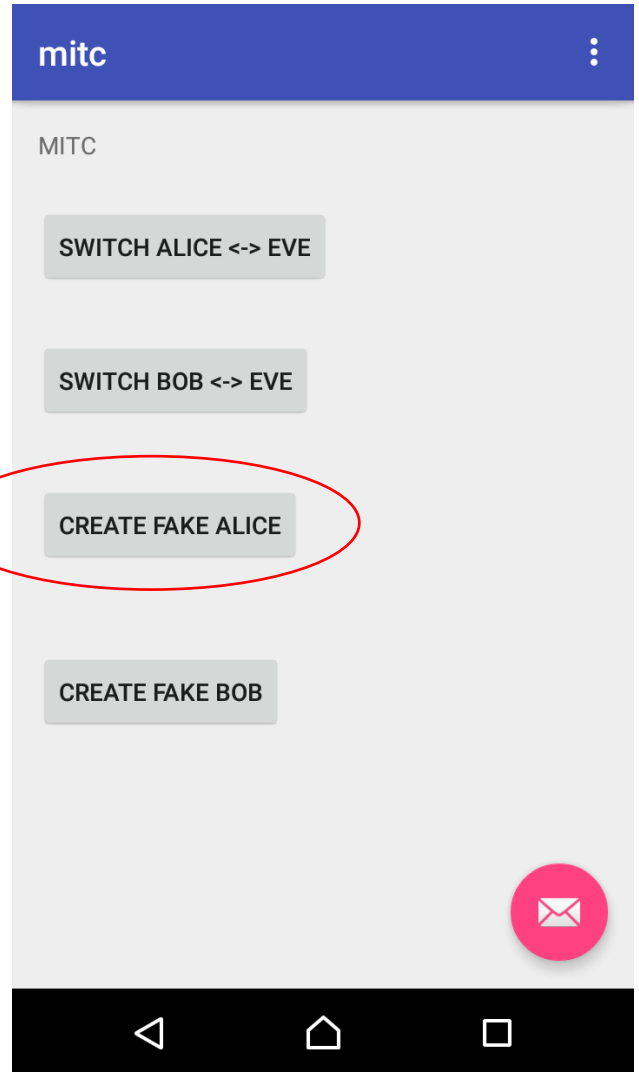
- Can't be used to trick Bob within an existing conversation
- But produces a notification and a new conversation that may seem legitimate to Bob

- Different behaviors depending on the app
  - Name in the notification vs name in the conversation
  - Name configured by the sender vs contact name as seen by receiver
  - Contact sync time

- Not discrete in case Alice and Bob have a phone call or send a message

# Nasty trick: contact with similar name

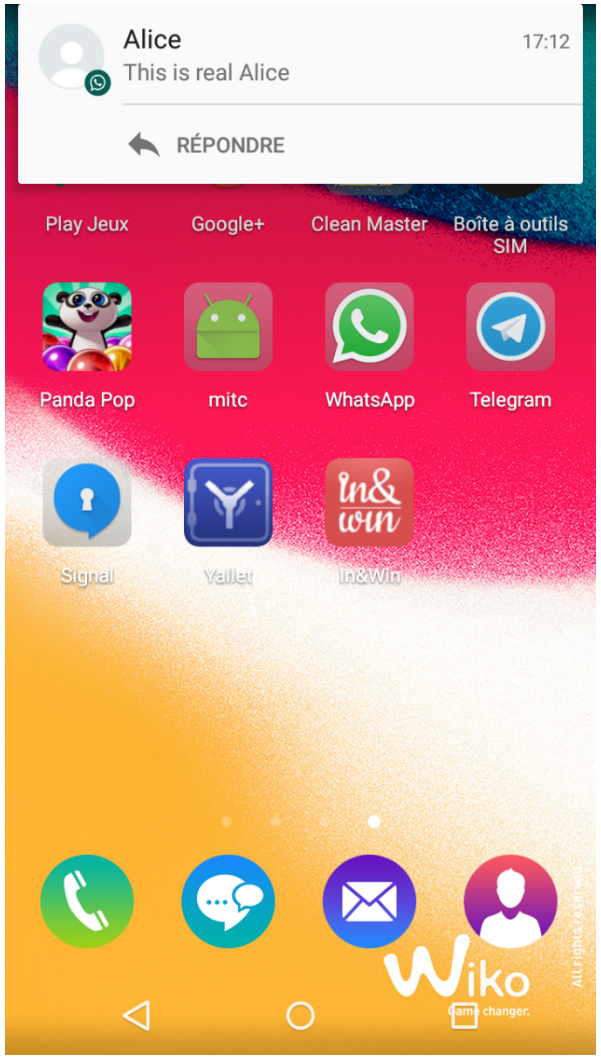
- Start a conversation between Alice and Bob
- Create a contact name **« Alice»** on Bob's device with Eve's phone number
- See how the **whitespace** in front of Alice gets displayed




Bob

# Nasty trick: contact with similar name

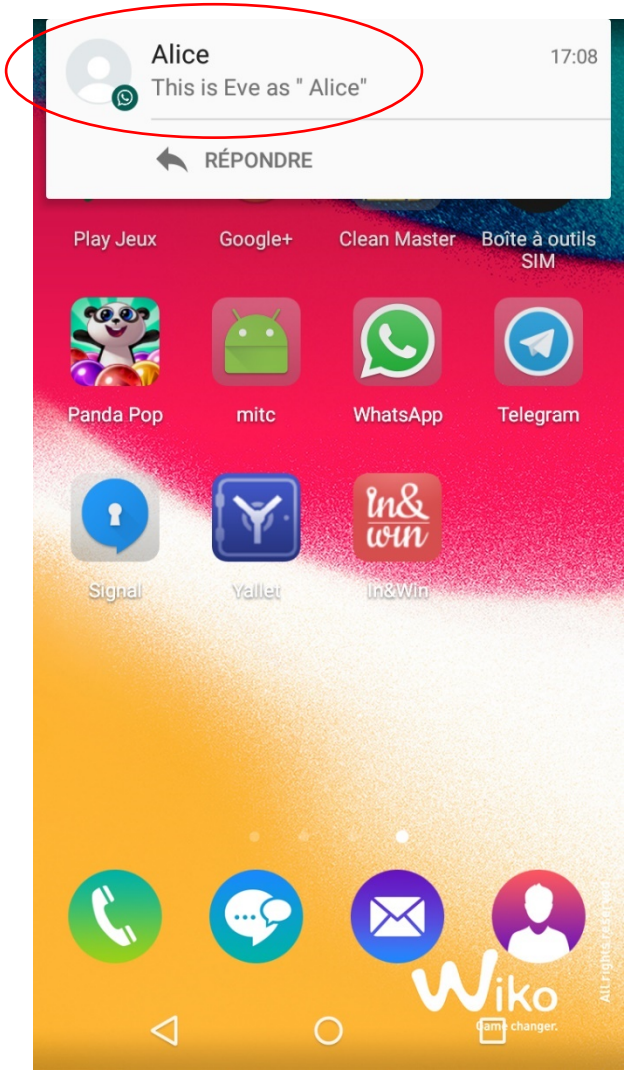
- WhatsApp 1
- Alice starts a conversion with Bob




Bob

# Nasty trick: contact with similar name

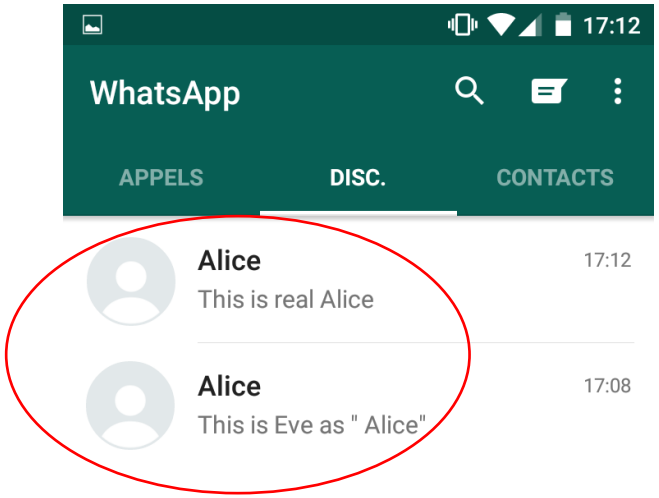
- WhatsApp 2
- Eve starts a conversion with Bob




Bob

# Nasty trick: contact with similar name

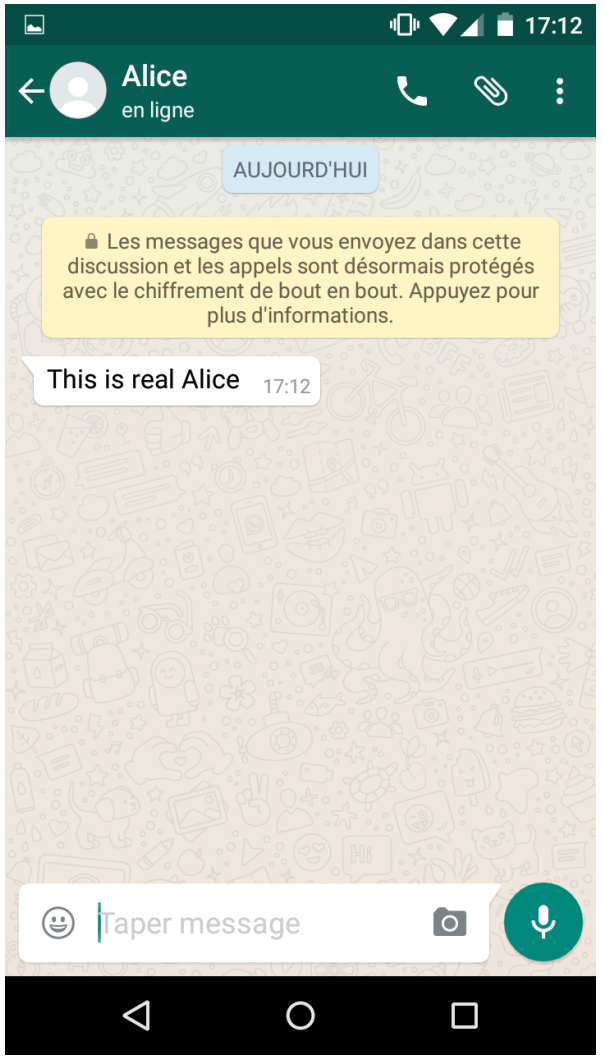
- WhatsApp 3
- Main view




Bob

# Nasty trick: contact with similar name

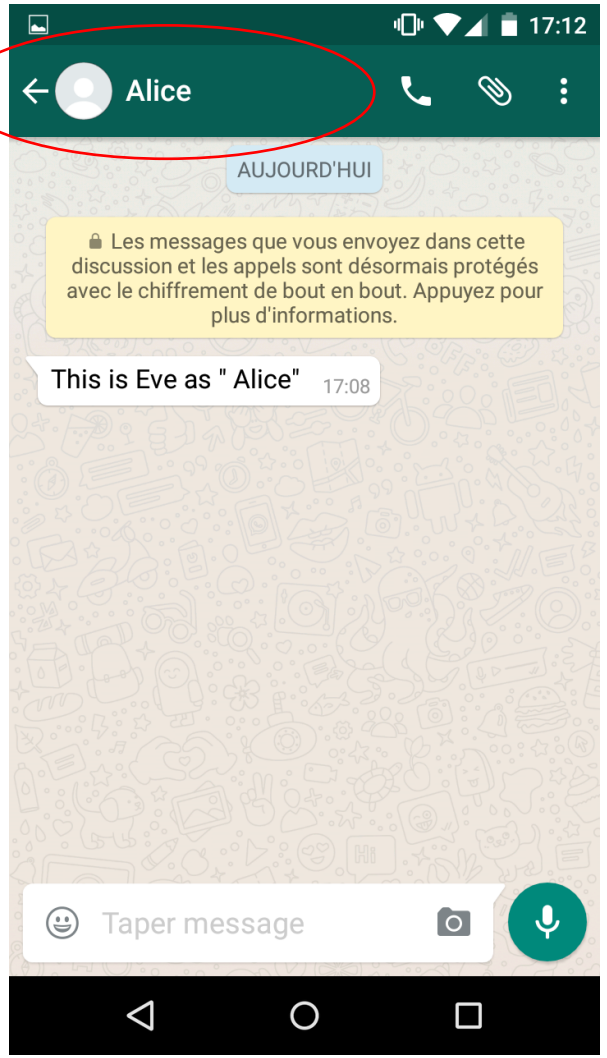
- WhatsApp 4
- Conversation with real Alice




Bob

# Nasty trick: contact with similar name

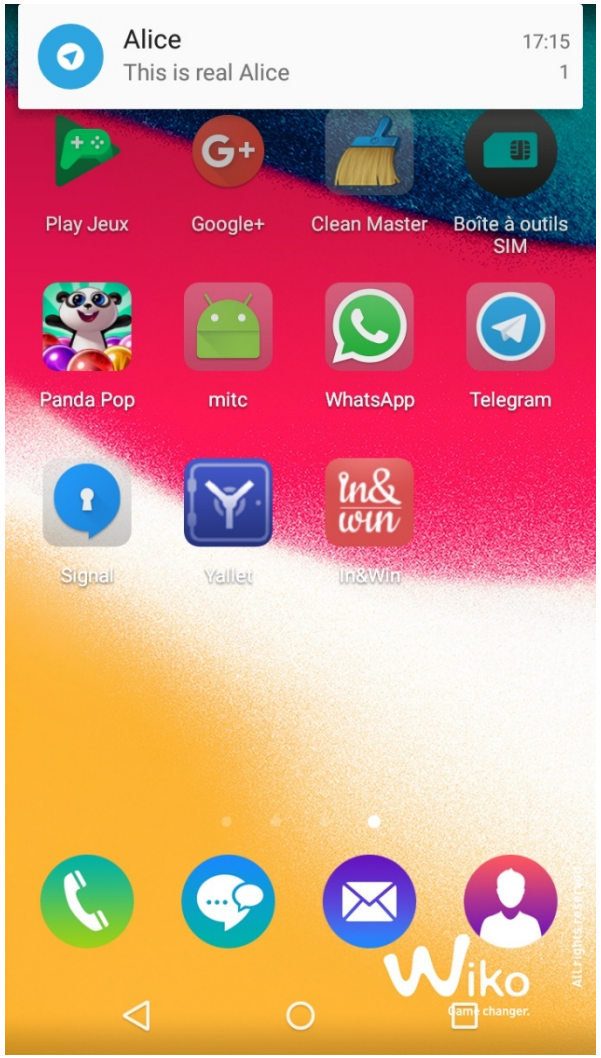
- WhatsApp 5
- Conversation with Eve as « Alice»




Bob

# Nasty trick: contact with similar name

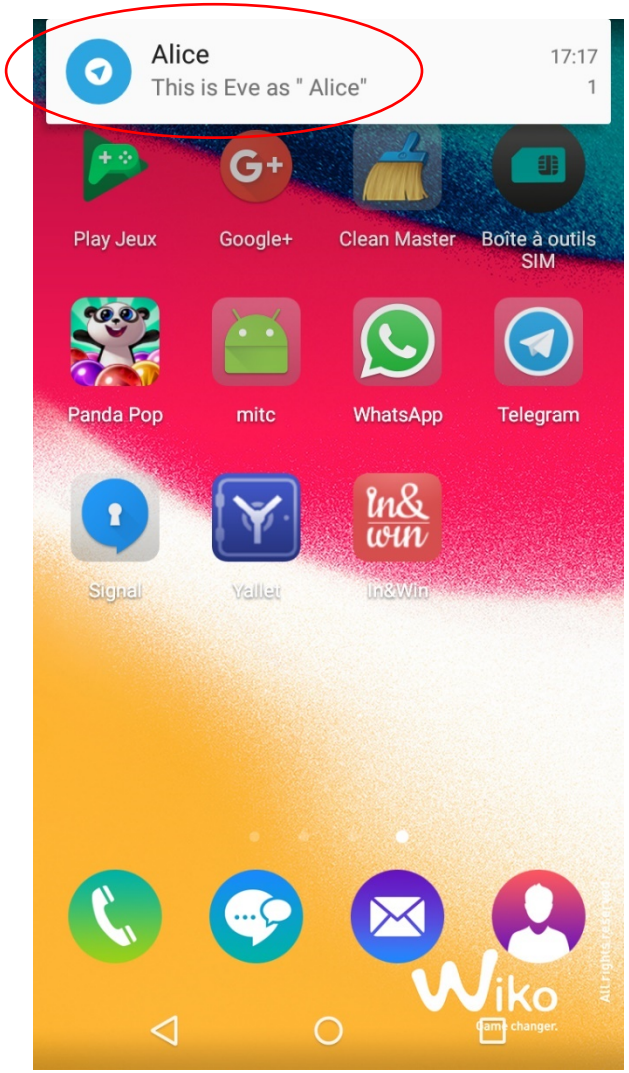
- Telegram 1
- Alice starts a conversion with Bob




Bob

# Nasty trick: contact with similar name

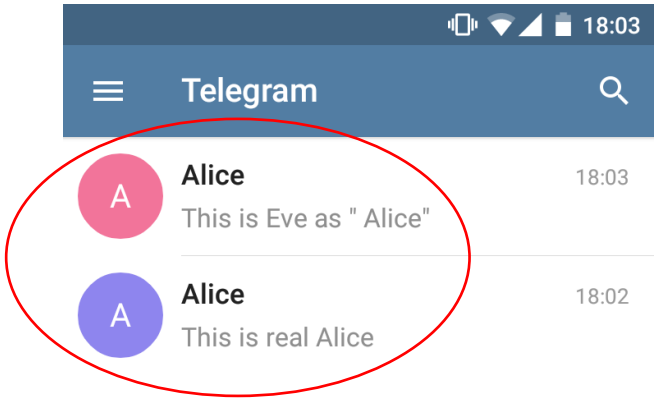
- Telegram 2
- Eve starts a conversion with Bob

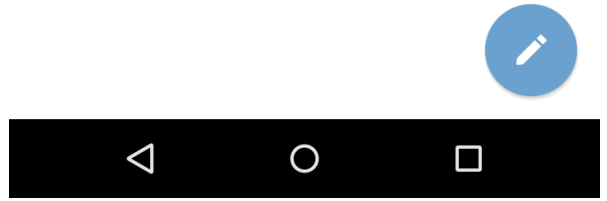



Bob

# Nasty trick: contact with similar name

- Telegram 3
- Main view

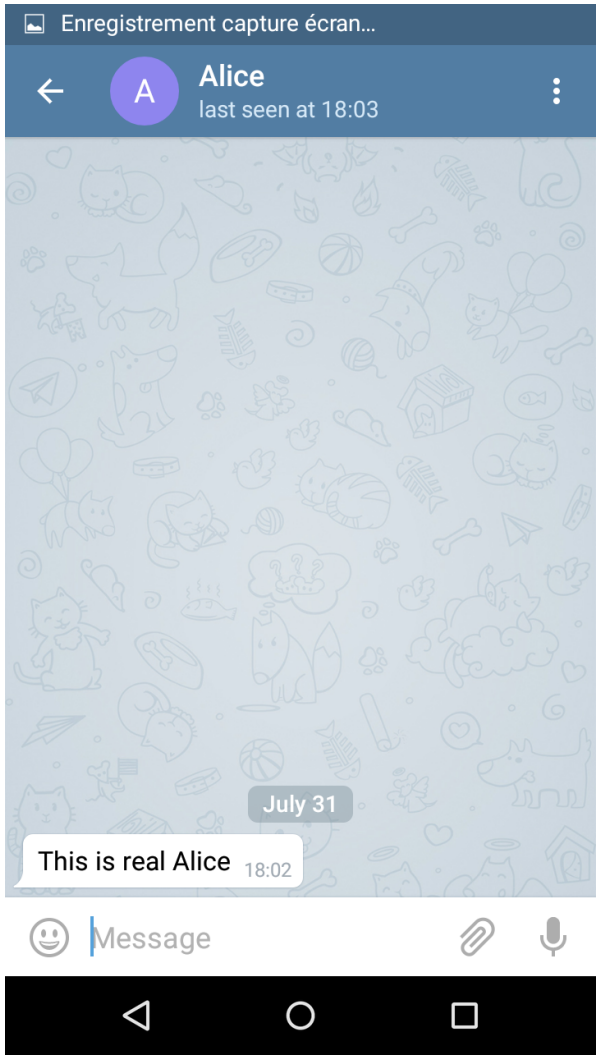


Bob

# Nasty trick: contact with similar name

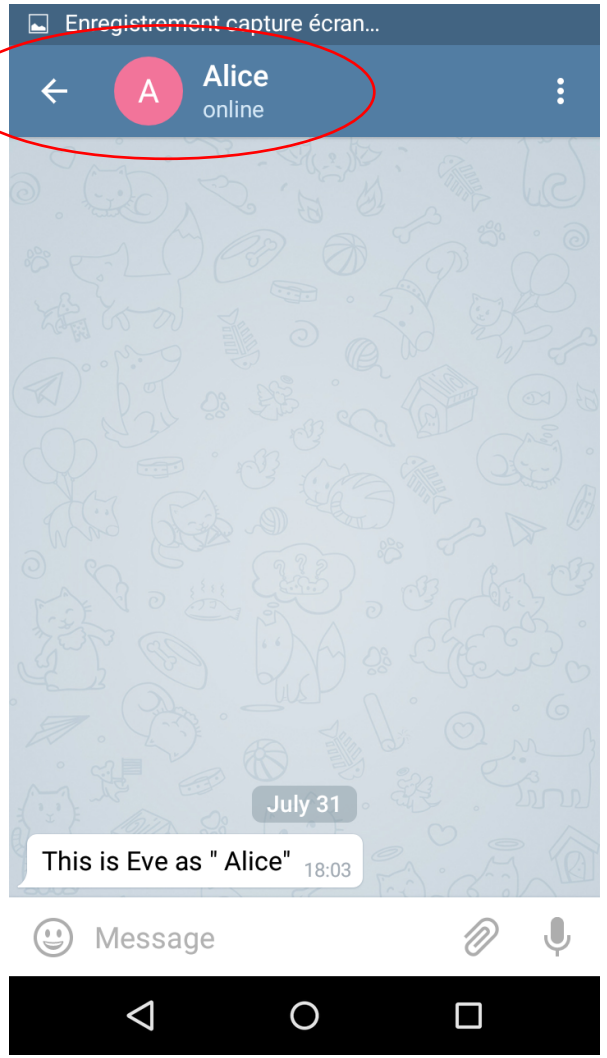
- Telegram 4
- Conversation with real Alice




Bob

# Nasty trick: contact with similar name

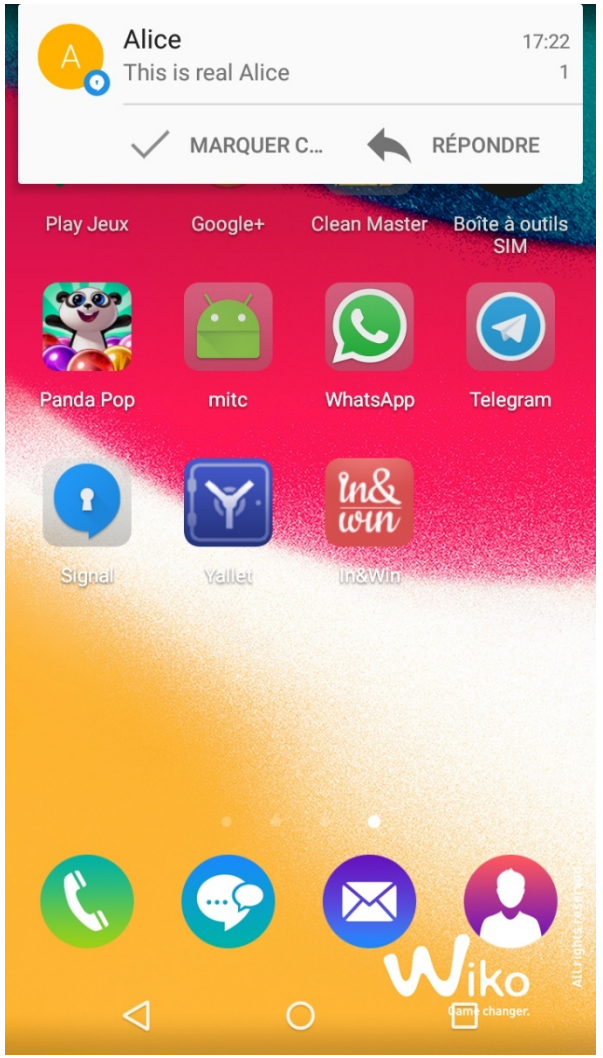
- Telegram 5
- Conversation with Eve as « Alice»




Bob

# Nasty trick: contact with similar name

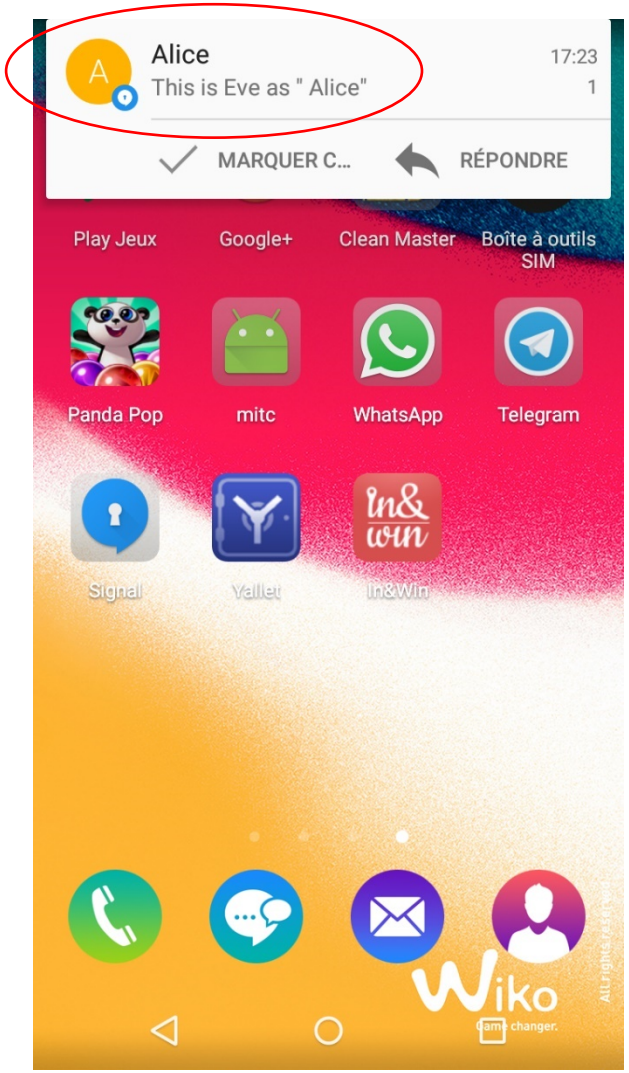
- Signal 1
- Alice starts a conversion with Bob




Bob

# Nasty trick: contact with similar name

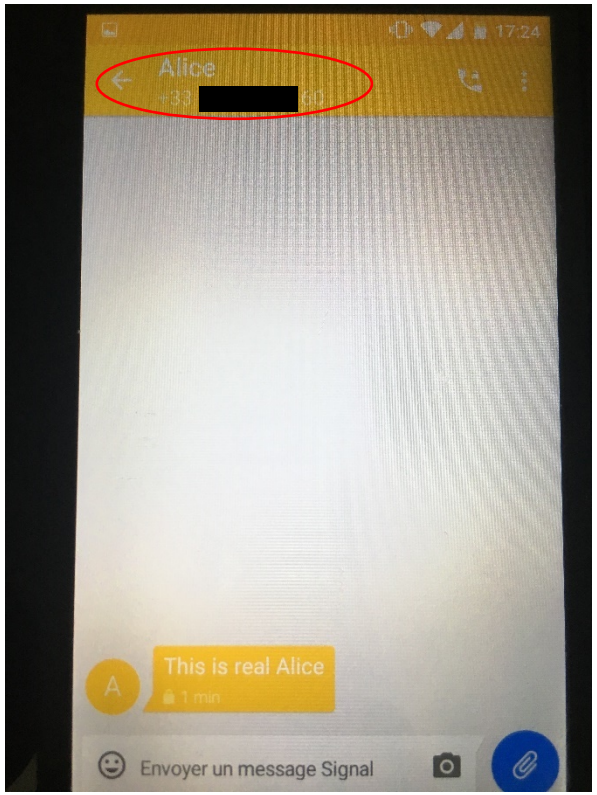
- Signal 2
- Eve starts a conversion with Bob




Bob

# Nasty trick: contact with similar name

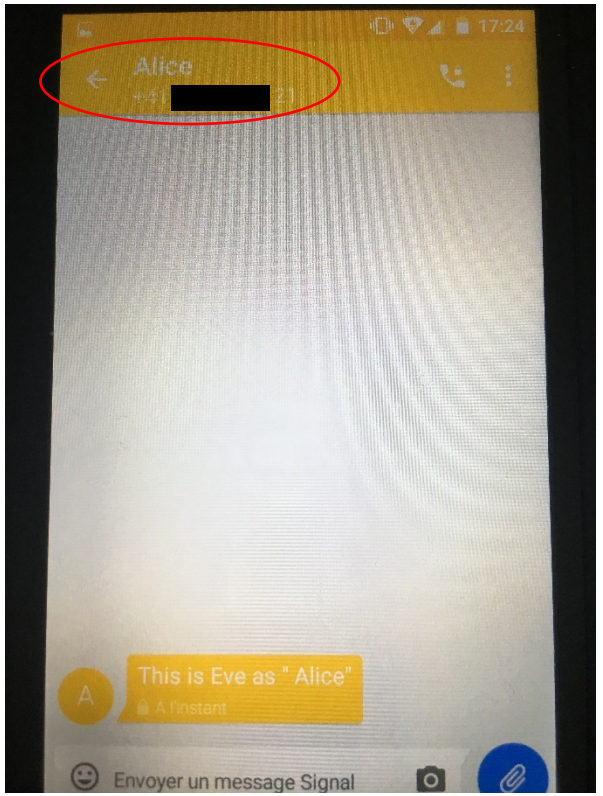
- Signal 4
- Conversation with real Alice




Bob

# Nasty trick: contact with similar name

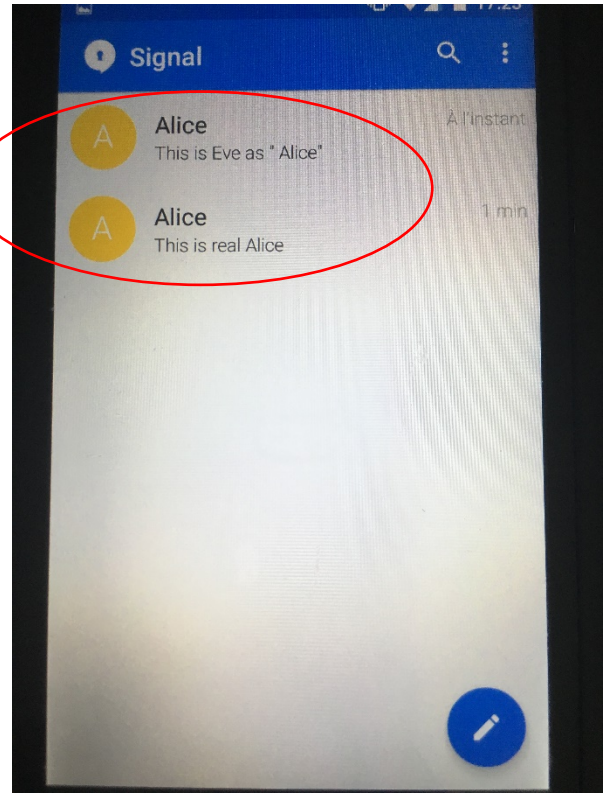
- Signal 5
- Conversation with Eve as « Alice»




Bob

# Nasty trick: contact with similar name

- Signal 3
- Main view




Bob

# Contact with similar name results

- Creating « Alice» in addition to Alice is far more discrete
  - Phone call/SMS OK with real contact
  - Whitespace prefix is not visible in messaging apps
  - Requires a new contact, but MITC app can delete/recreate « Alice» as often as needed

- **Why does it work ?**
  - **Design error** from a security point of view: **phone number poor identifier**
  - **Abusing TOFU**: new contact = new key = accepted by default
  - **End user/mobile not really included in threat model**
    - Focus on protecting network/backend (e.g. against government agencies)
    - Side channel attack with some social engineering out of scope
- Yet after a few messages, Bob can guess it is not really Alice speaking to him

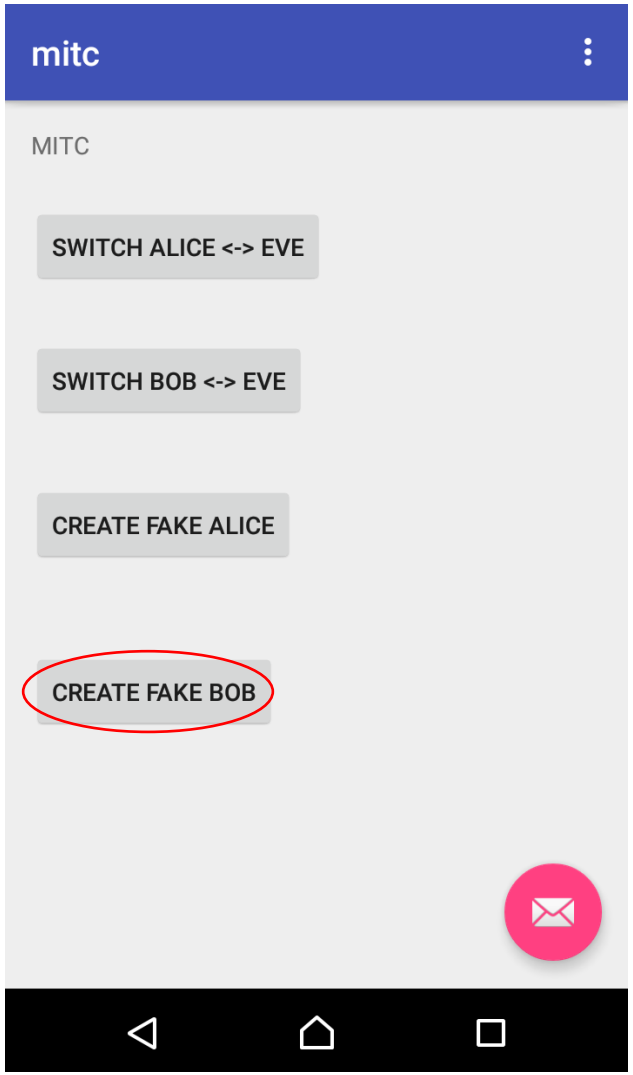
# Building an attack scenario with MITC

- Let's build an easy exploitation scenario

- Convinced many more similar attacks are possible
  - Look in detail in the implementations how contacts are handled
    - Reverse engineering for WhatsApp/Telegram
      - Highly likely Java readable code for handling the Android contacts
    - Open source code for Signal
  - Extra identifiers stored in contacts: they can also be modified !

- **Suppose Alice also installed the MITC app**
  - because it's very popular
  - or MITC app sends her a SMS recommending to do so because it found her in Bob's contacts

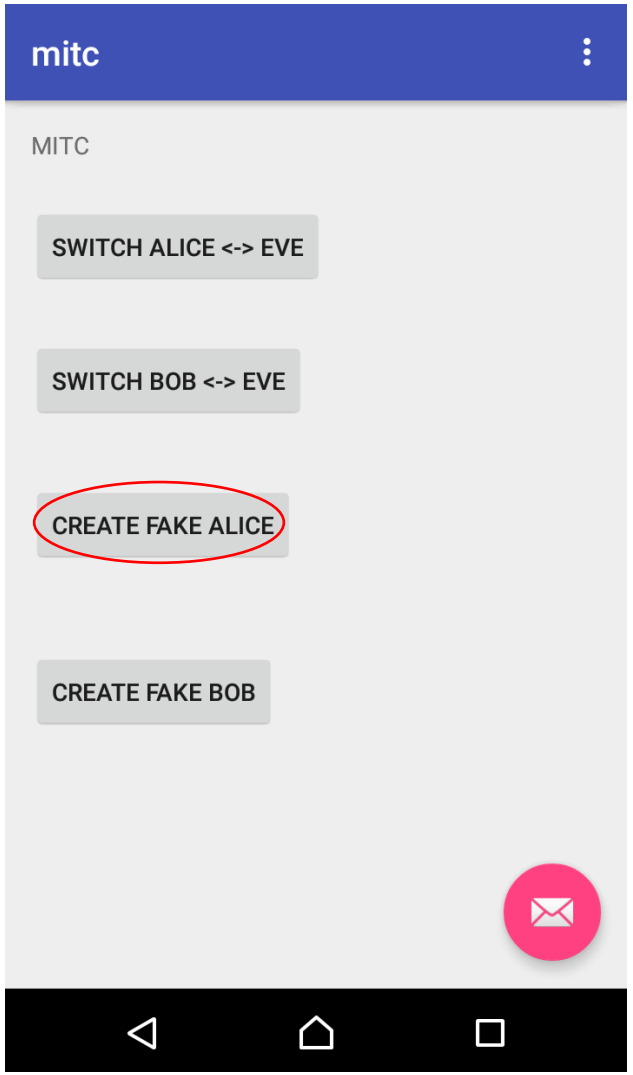
# Man In The Middle: init phase




Alice

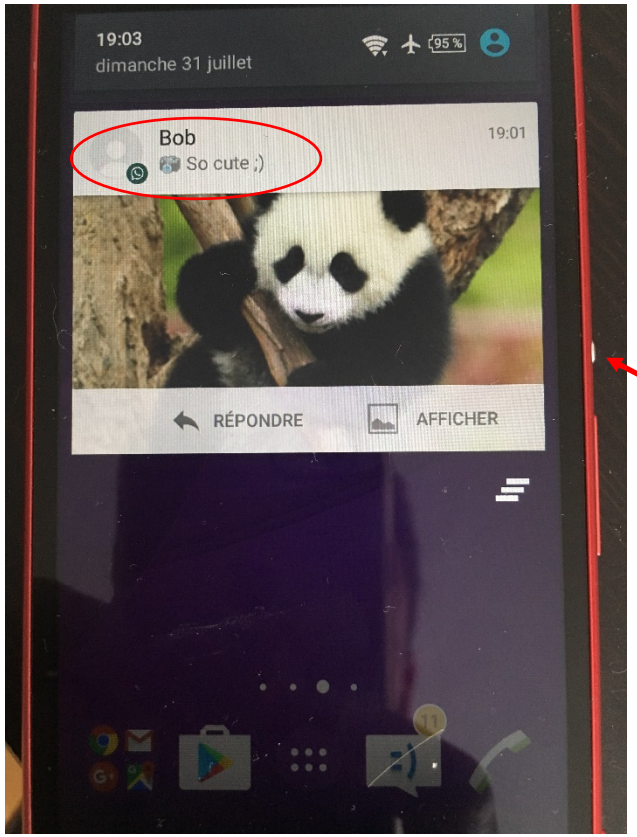
- 1. Have MITC deployed on the devices of Alice and Bob
- 2. Login as Eve to **web version of messaging app**
- 3. Create « Alice» and « Bob» with Eve's phone number via MITC app

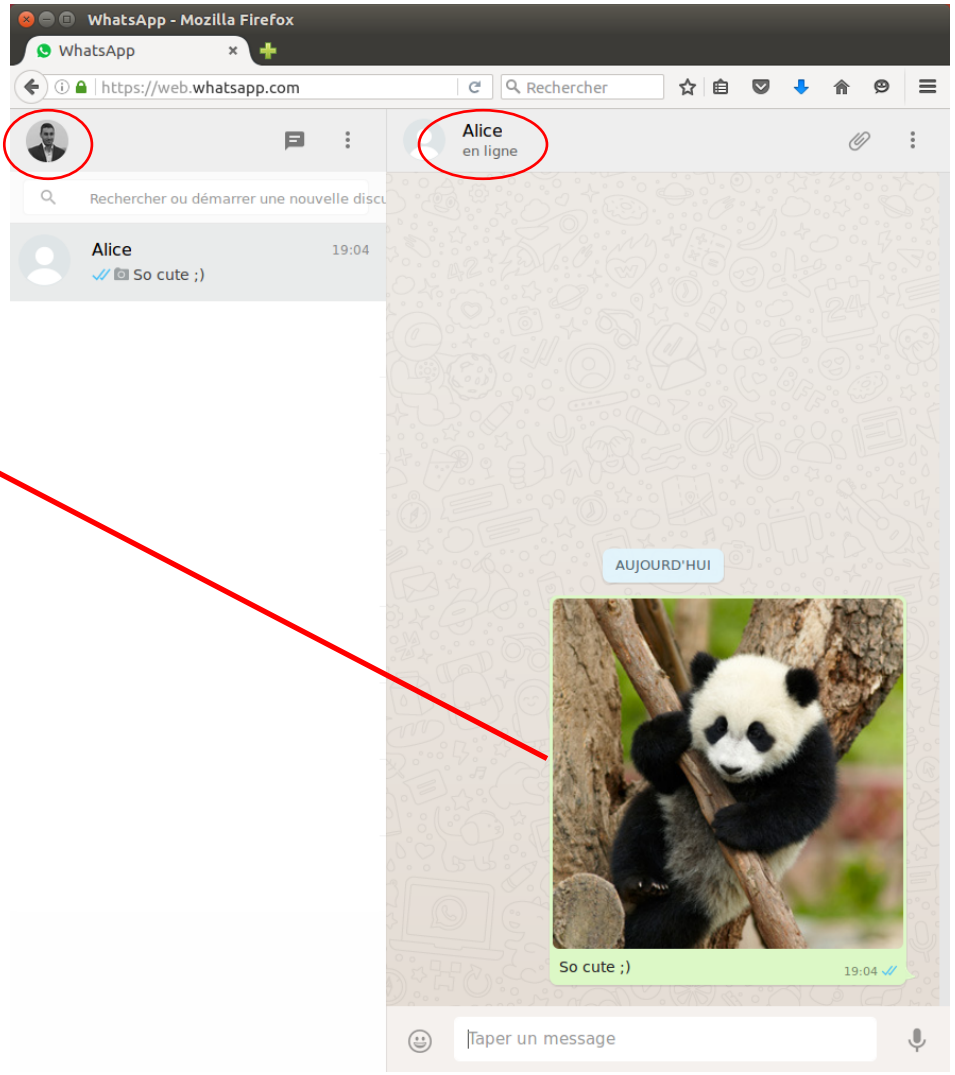
Eve




Bob

# Man In The Middle: provoke discussion 1



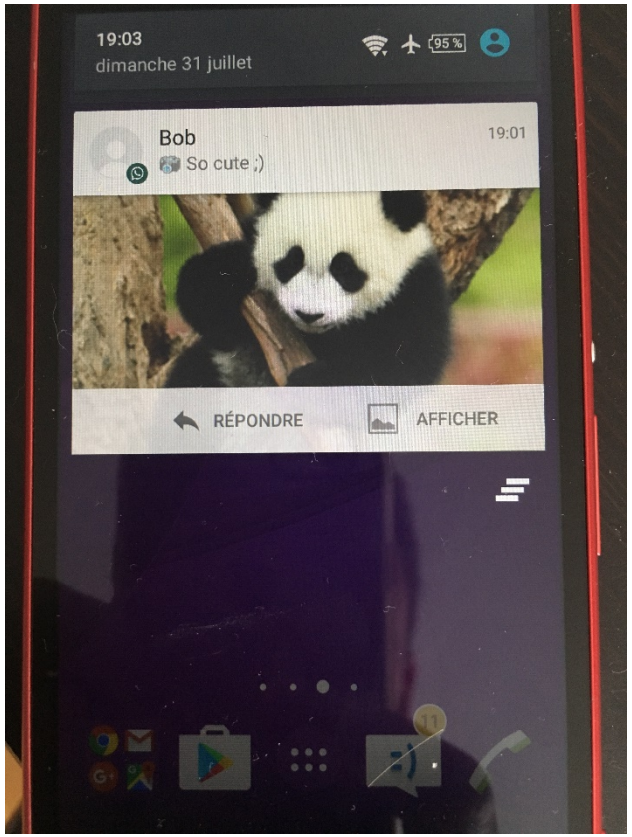




Alice

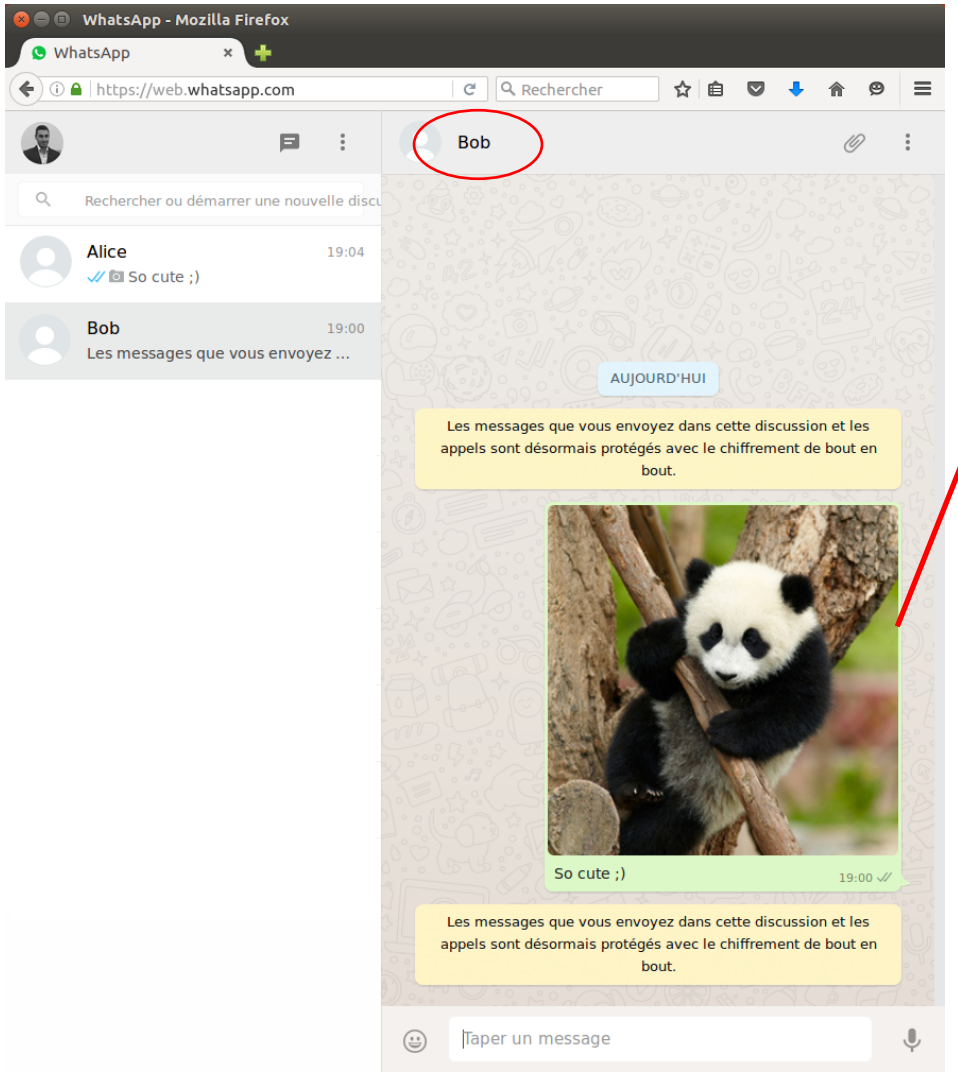
Eve

Bob

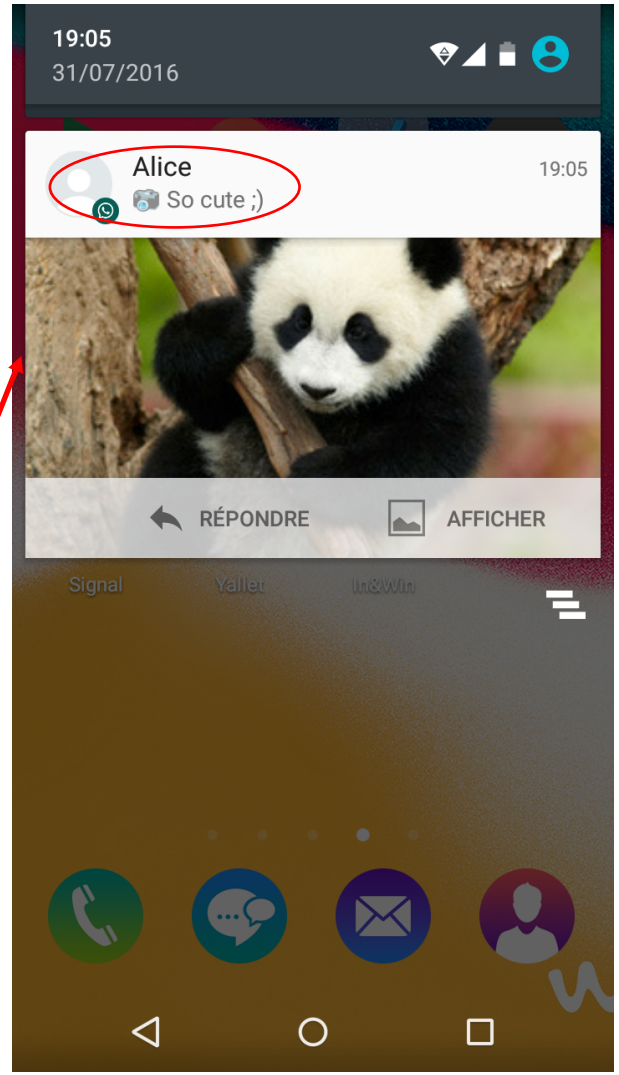
# Man In The Middle: provoke discussion 2




Alice

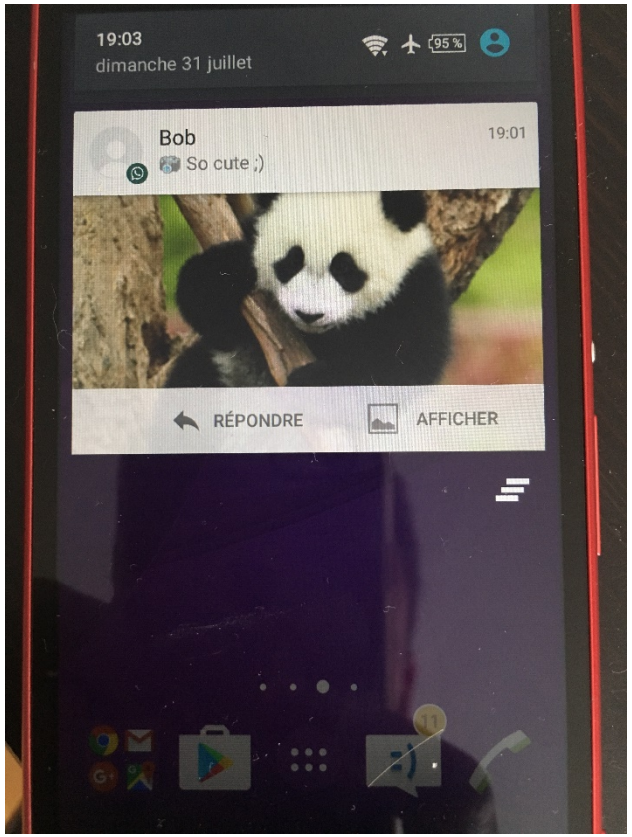



Eve

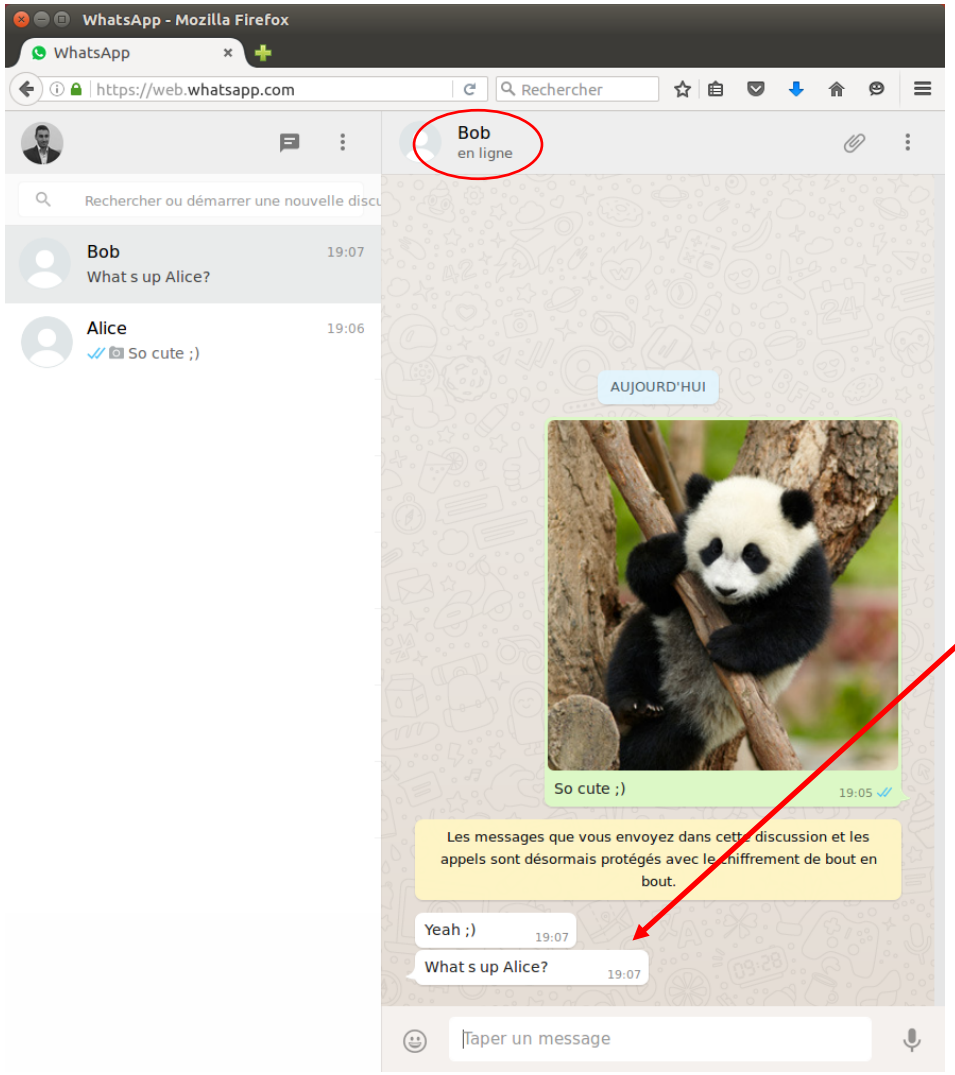



Bob

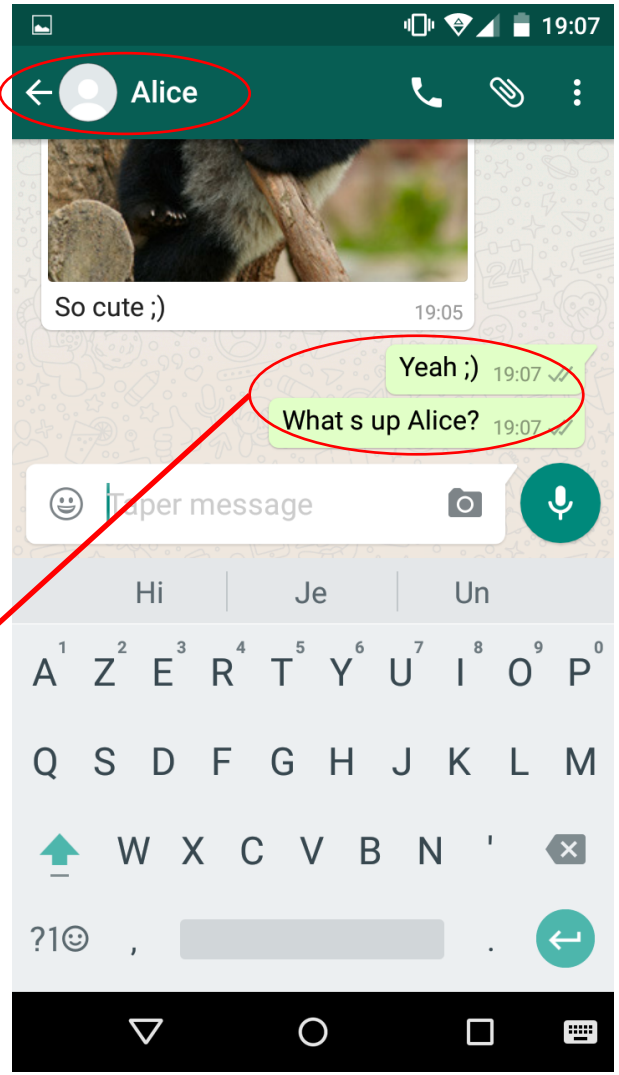
# Man In The Middle: discussion 1




Alice

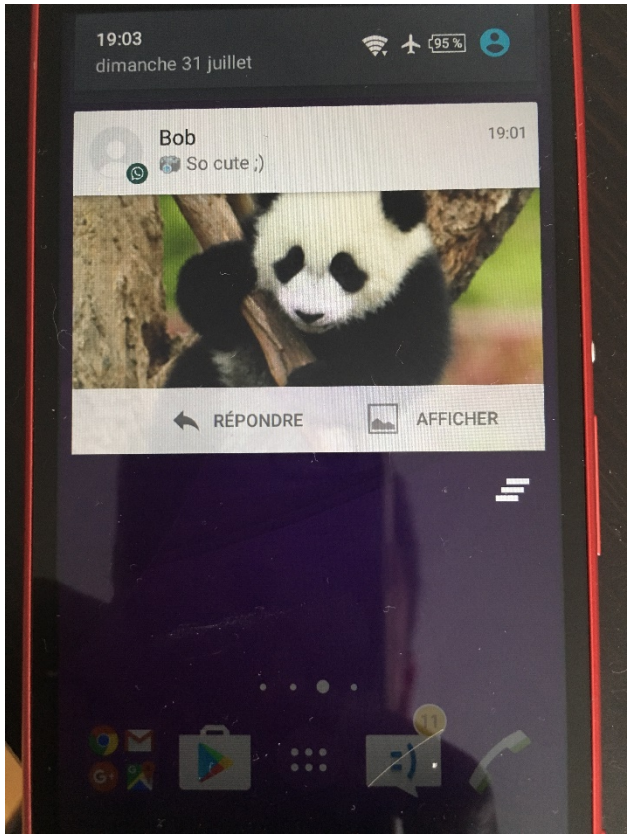



Eve

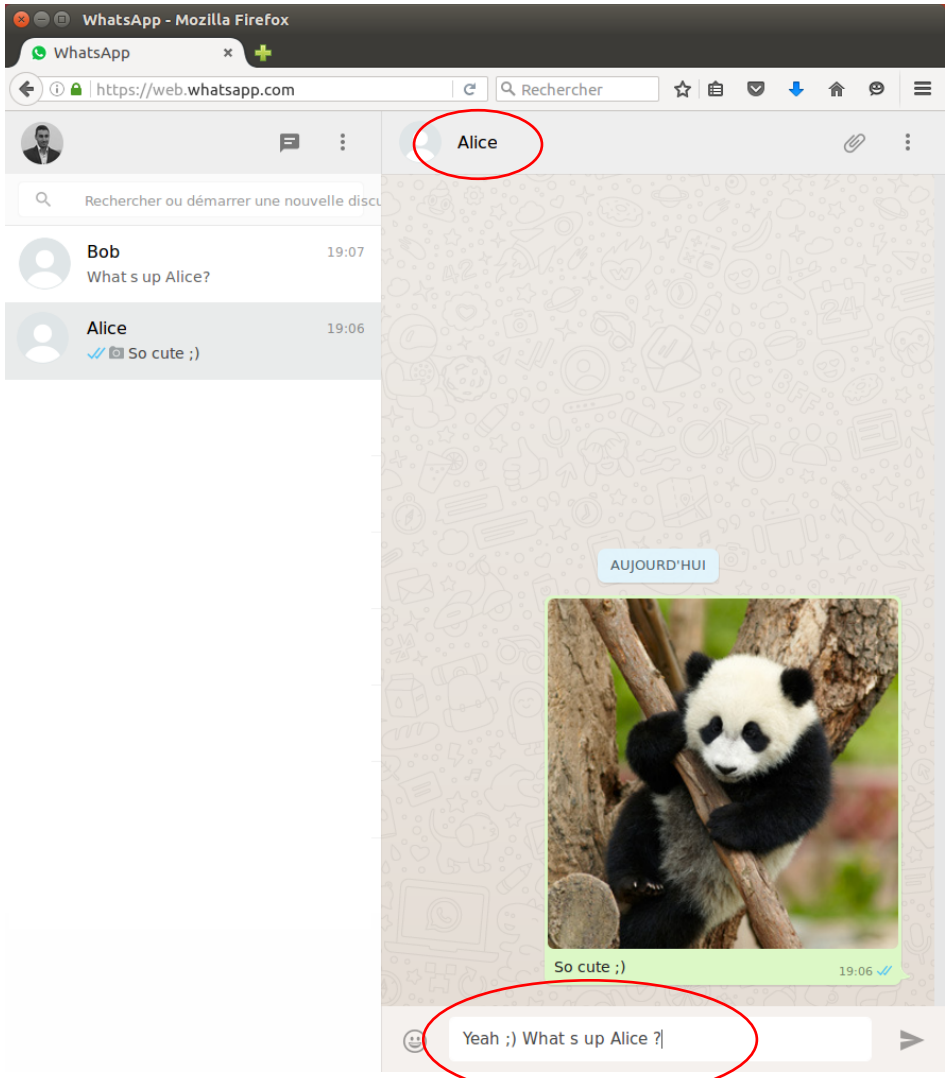



Bob

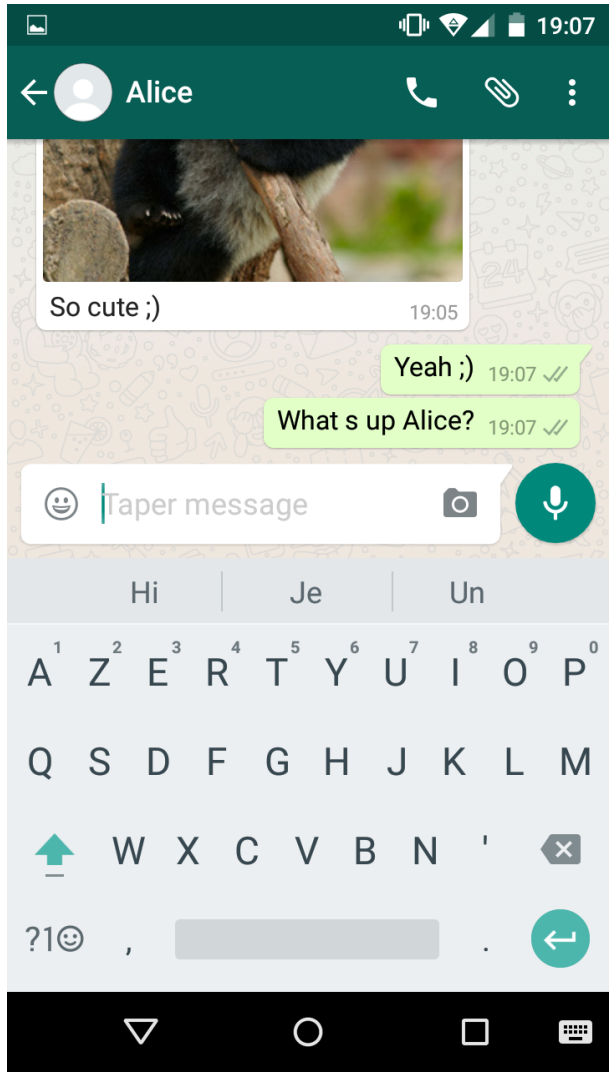
# Man In The Middle: discussion 2




Alice

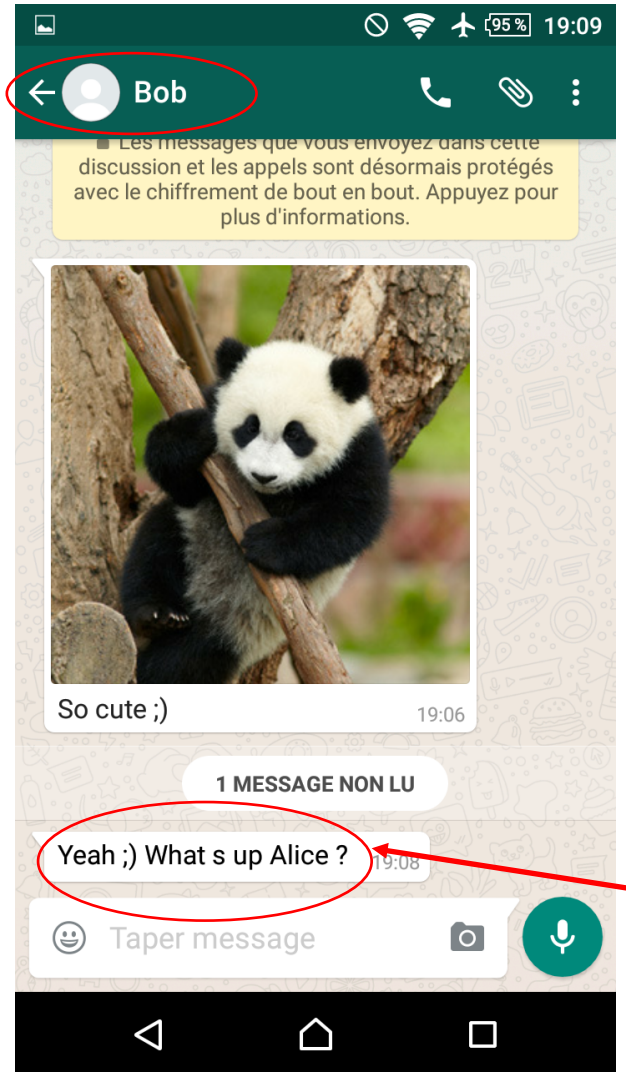



Eve

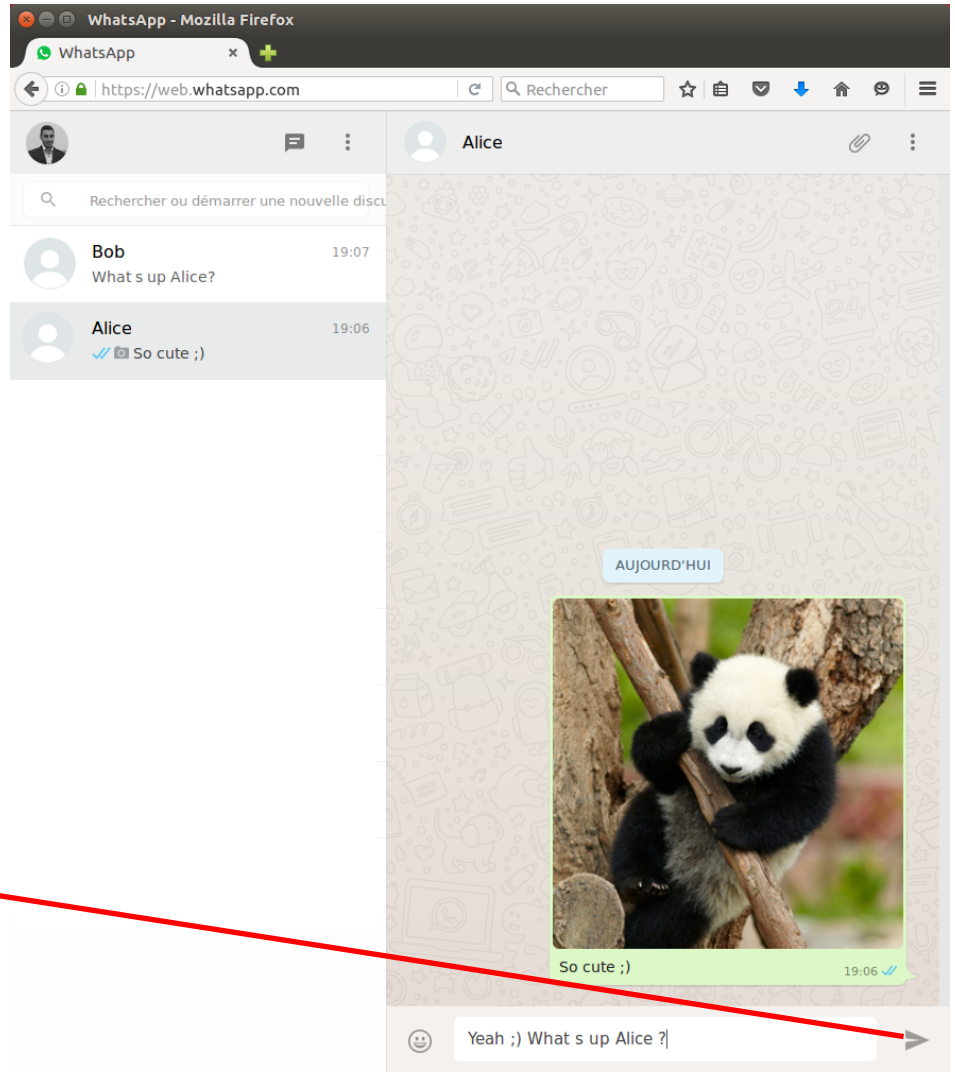



Bob

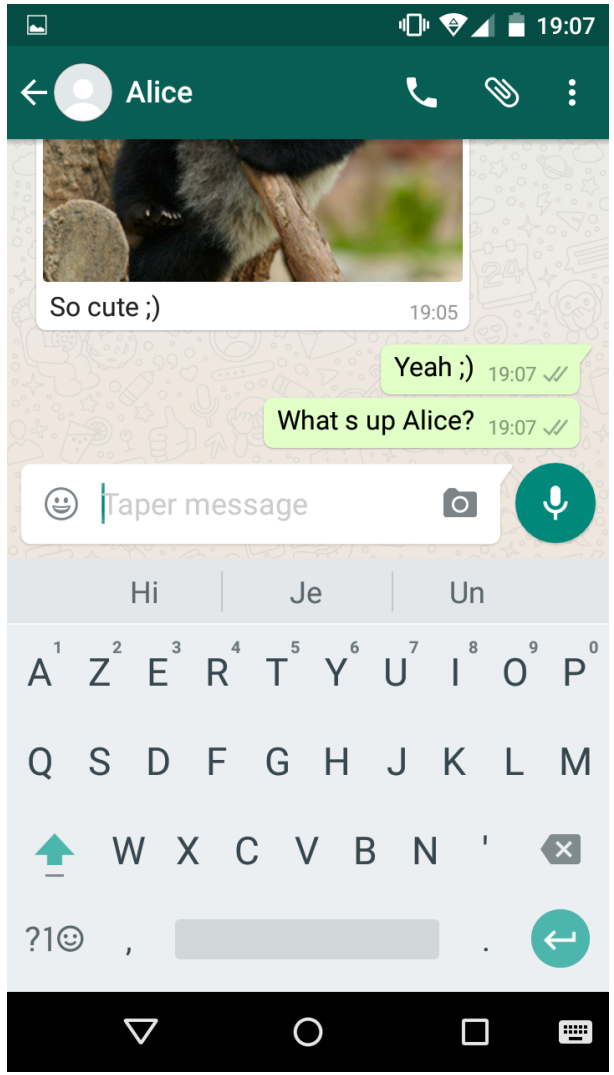
# Man In The Middle: discussion 3




Alice

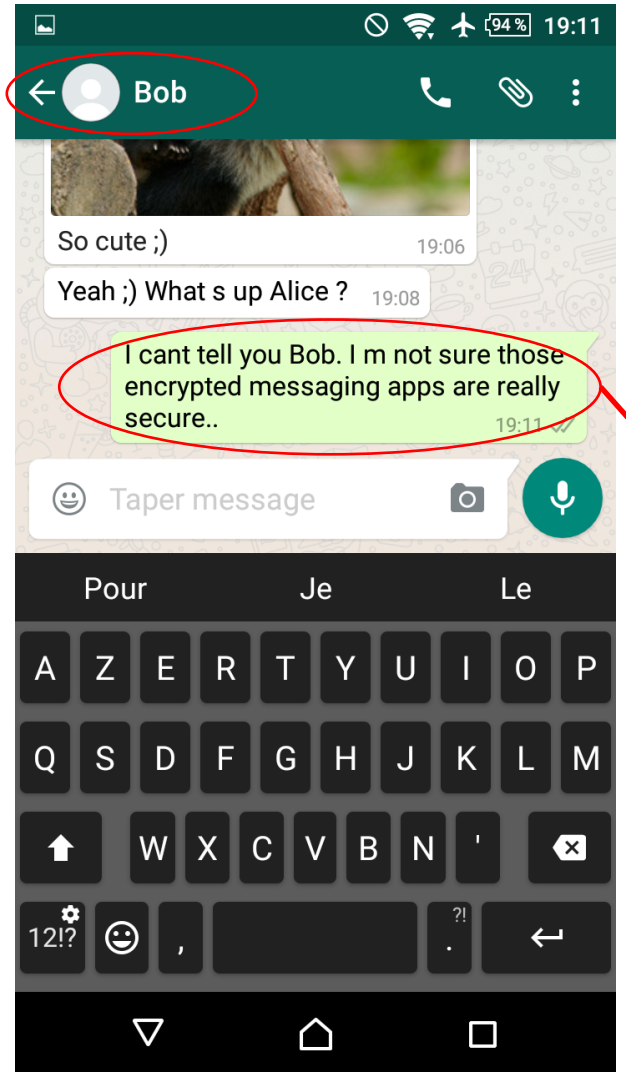



Eve

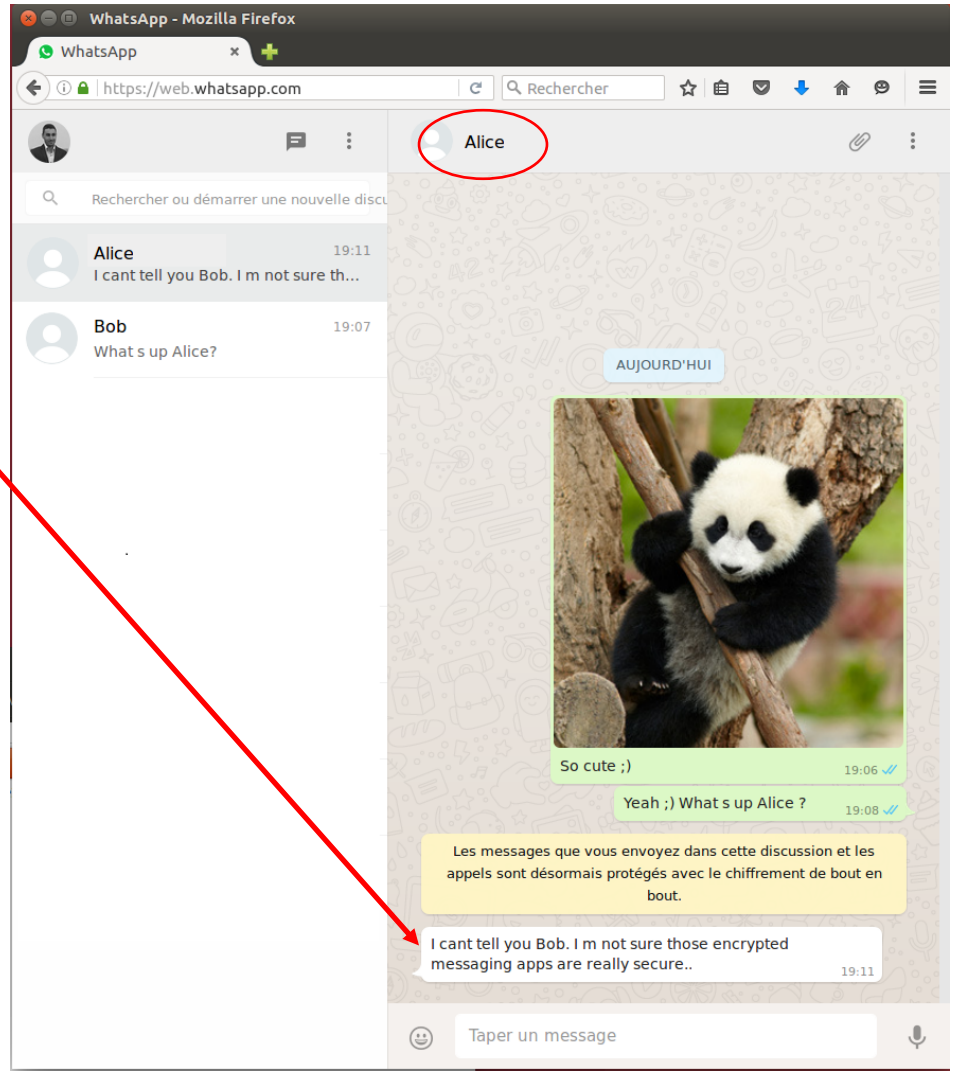



Bob

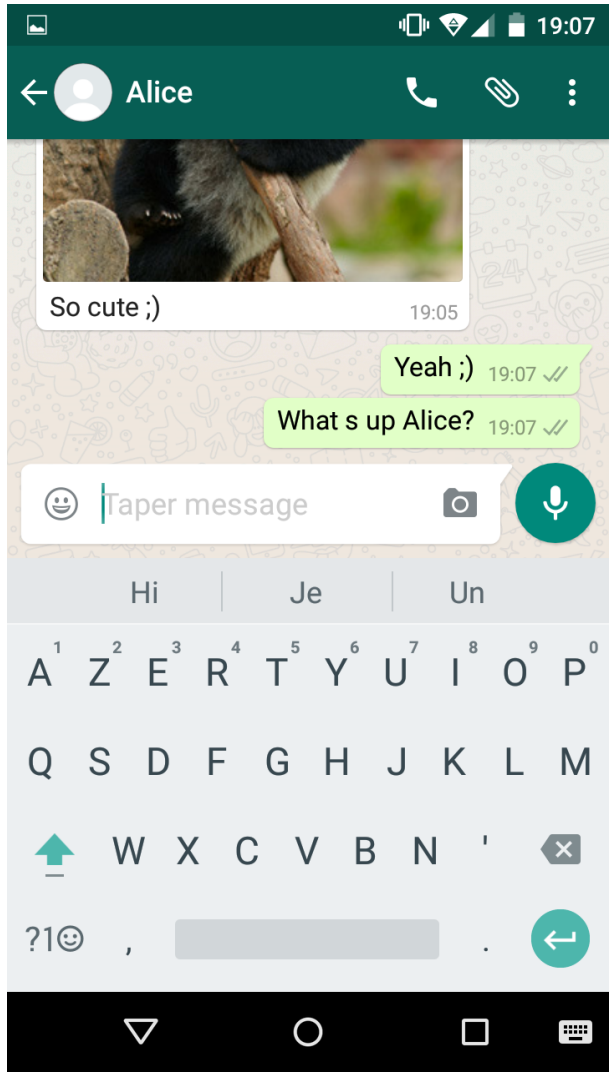
# Man In The Middle: discussion 4




Alice



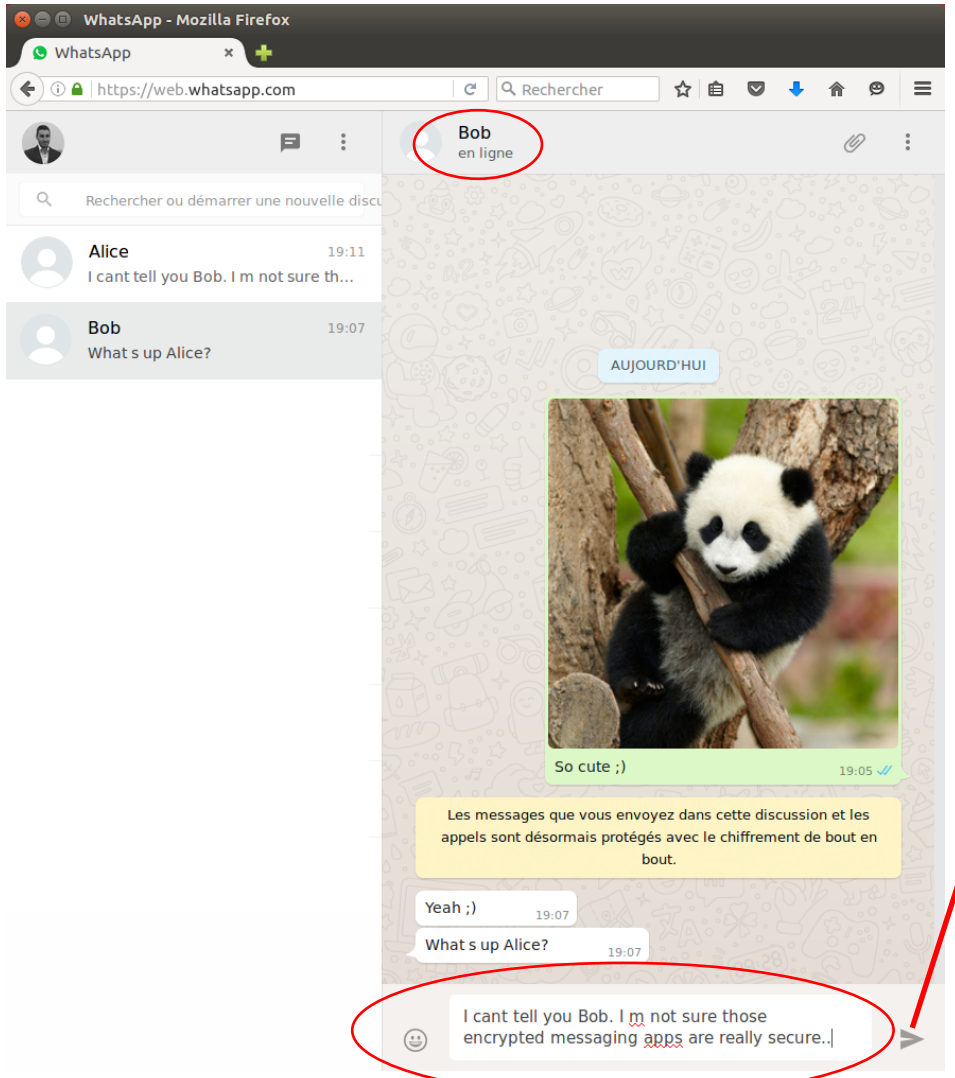

Eve



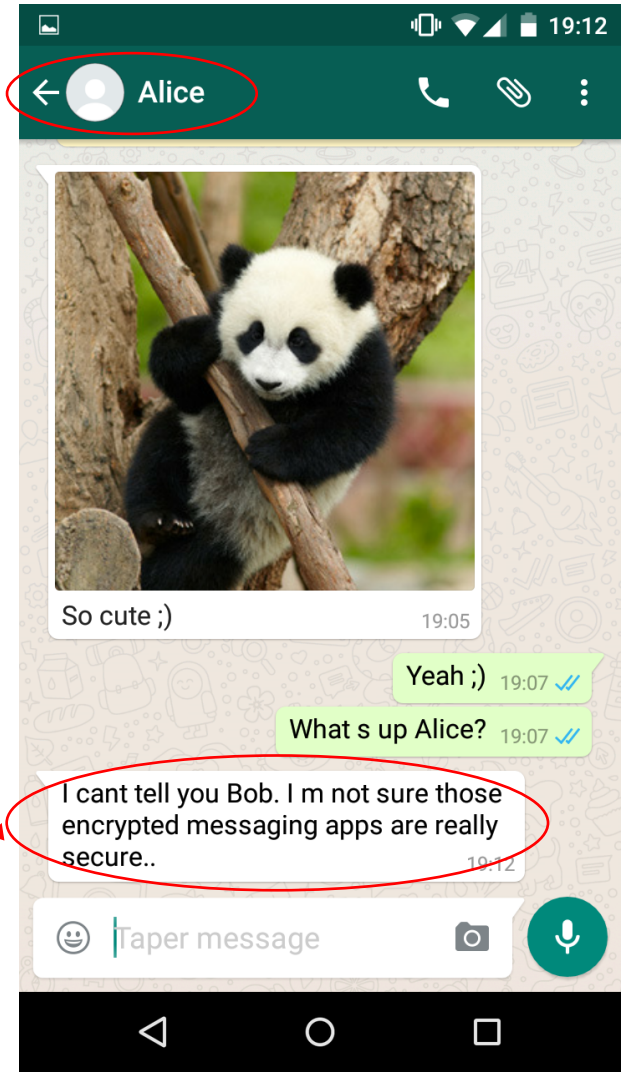

Bob

# Man In The Middle: discussion 5


Alice




Eve




Bob

# Man In The Middle results

- WhatsApp
  - **Possible to share a real conversation between Bob and Alice via Eve**
  - Only need to switch to a new conversation by forcing a chat
  - Later conversations will likely continue in this session (UI easiest path)
- Telegram: same results (web version also available), as long as the new contacts are used for the first time
- Signal: same results
  - Phone number always displayed below contact name (Android version only)

# Risk assessment

- Simple evaluation: risk = easiness of attack * user impact
- Difficulty of attack: Low-Medium
  - Technically: Low
    - Easy to access contacts via code
    - Not a problem to get MITC application approved for publication
  - Logistics : Medium
    - One phone number is enough
    - Need to convince many users to install the MITC application
    - But « Ponzi scheme » possible by using the contact information
- Impact: High
  - Thousands of users can be spied: multi-app + multi-mobile os

| Difficulty to attack | Low business impact | Medium business impact | High business impact |
|---|---|---|---|
| **Low** | Low | Medium | Very High |
| **Medium** | Low | Medium | High |
| **High** | Low | Low | Medium |

# Vendors feedback 1/4

- Telegram
  - Very efficient Level 1 support (a contact in Telegram app)
  - Level 2: security@telegram.org = **/dev/null**
    - Contacted them 3 times
    - Asked Level 1 to recontact them
    - Public question via Twitter
- WhatsApp
  - Contact Facebook security via form => automatic confirmation
  - No answer for one month
  - Recontacted them: answer received the next day
  - Replied to it, but never got feedback

# Vendors feedback 2/4

- WhatsApp answer (layout as is, bold added)

We appreciate your report. **Ultimately** an attacker with **malware** installed on a device is going to be able to alter data on the device itself. In your examples for **WhatsApp conversations remained properly bound to the phone number that the messages were sent to**. Beyond that, WhatsApp allows people to **set local aliases for contacts** and to view the number associated with a specific message thread at any point. Given that, we don't feel that this behavior poses a significant risk and **we do not plan to make any changes here**. Please **let us know if you feel we've misunderstood something** here!

# Vendors feedback 3/4

- Signal
  - Not clear what is the channel for security issues
  - Create report for Android app in Signal bug tracking tool
  - Recontacted twice but no answer for 2 months
  - Public question via Twitter
    - Quick answer from support
    - Someone from tech team will contact me soon
  - After recontacting support, discussion started

# Vendors feedback 4/4

- Signal 1st reply (layout as is, bold added)

  Hey Jeremy, saw your support email about "man in the contacts." This, like all interception techniques, is **what safety numbers are for**. **Signal users would be notified that** the safety numbers for **their contact have changed**, and be asked to verify them. A successful MITM attack would need to find a way to intercept communication without triggering that notice.

- Signal 2nd reply (layout as is, bold added)

  Hey Jeremy, **Signal is not designed to protect your device against malware**. Thanks for getting in touch, good luck with everything.

# Countermeasures: mobile apps

- Give up the implicit trust on contacts
  - Deal with contacts the old way
    - Provide an explicit identifier + authentifier
    - Manually approve contacts to be added
- Or mitigate risk by increasing user awareness
  - Clear message when a new conversation starts explaining to be cautious
    - Ideally warning sign in the corresponding notification
  - Display a visible trust level indicator next to the contact name
    - If no chat history for this number/key, trust level set to minimum
    - Phone number can help (if people know the numbers by heart …)
- Mobile OS: stronger restrictions for accessing contacts

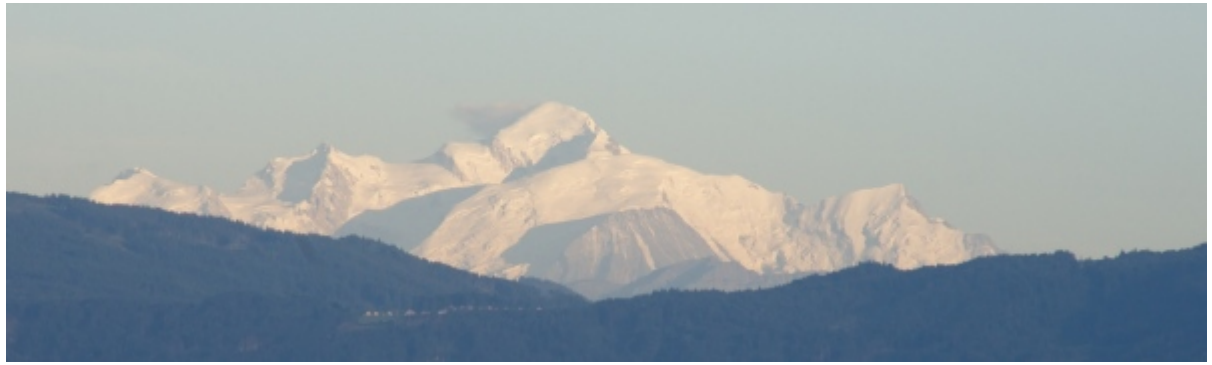
# Countermeasures: end user

- Check your contacts
- Avoid installing applications asking for modify contacts permission
  - Yes messagins apps ask for this permission …
- Use Threema
  - Swiss German app
  - Manual id handling
  - Optional contact sync
  - Visible trust level: Red/Orange/Green
  - Questions on contacts handling sent to press@threema.ch
    - Very detailed answer with the clear design choices received the next day

# Conclusion

- **E2E can't guarantee privacy if you're not sure who you're talking to**
  - Beware of messages displaying good cryptography is used because it can bring a false sense of security
- **Security model around contacts is far too open** for sensitive apps
- **Authenticating the other party is an absolute necessity**
  - But it's a difficult task, particularly the provisioning processes
  - And even more to make it user friendly
    - **The end user must be in the loop** to detect suspicious activity
    - If it's too complex, secure features won't be used
    - A significant part of end users will install crappy apps, accept anything and not care about security warnings
- If the design of your solution includes access to contacts, start a threat modeling session

# Thank you !



## Any question ?

contact@securingapps.com