Android build system

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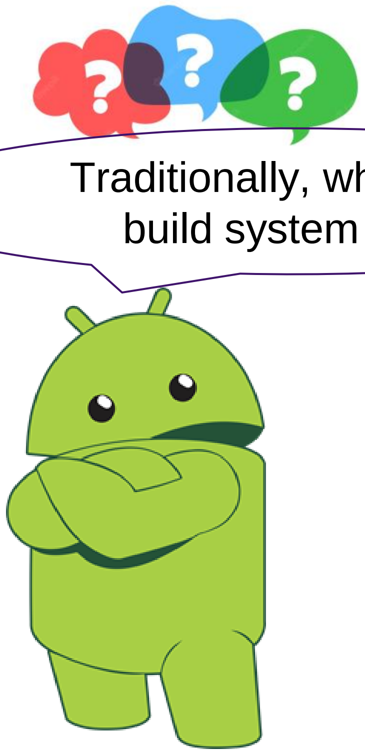
Oct-2024

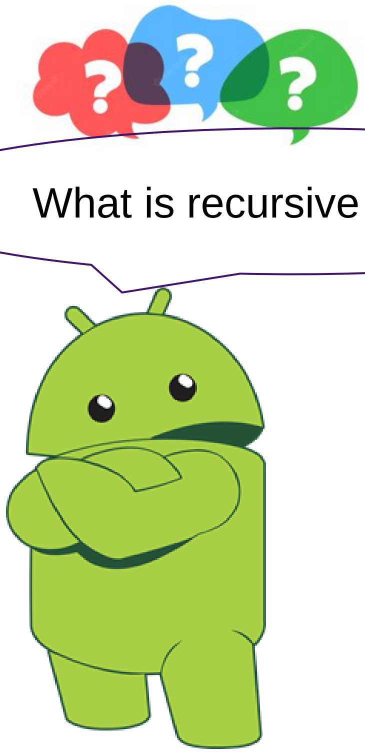
Day 3

QUIZ (1/10)

Traditionally, what does build system use?



QUIZ (2/10)



What is recursive makefile?

QUIZ (3/10)

Is there any issue with recursive makefile?

QUIZ (4/10)

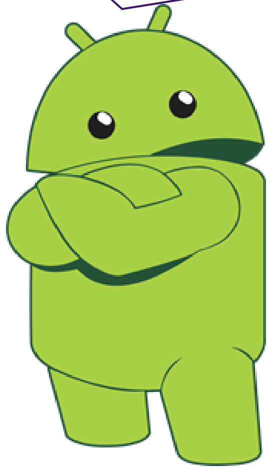
Tell me some problems with recursive makefile?

QUIZ (5/10)

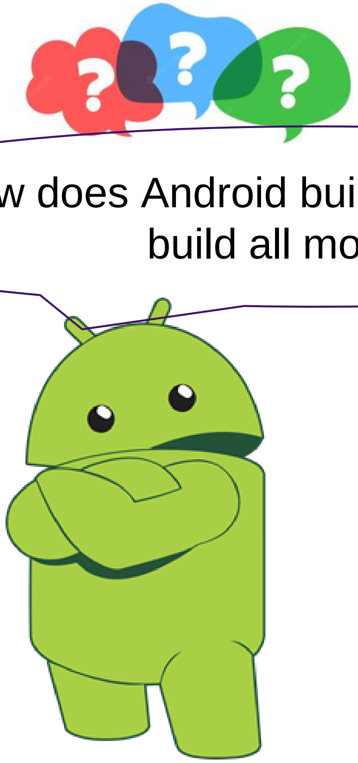
Does Android build system use recursive makefile?

QUIZ (6/10)

How does Android create the dependency tree?



QUIZ (7/10)



How does Android build system know to build all modules?

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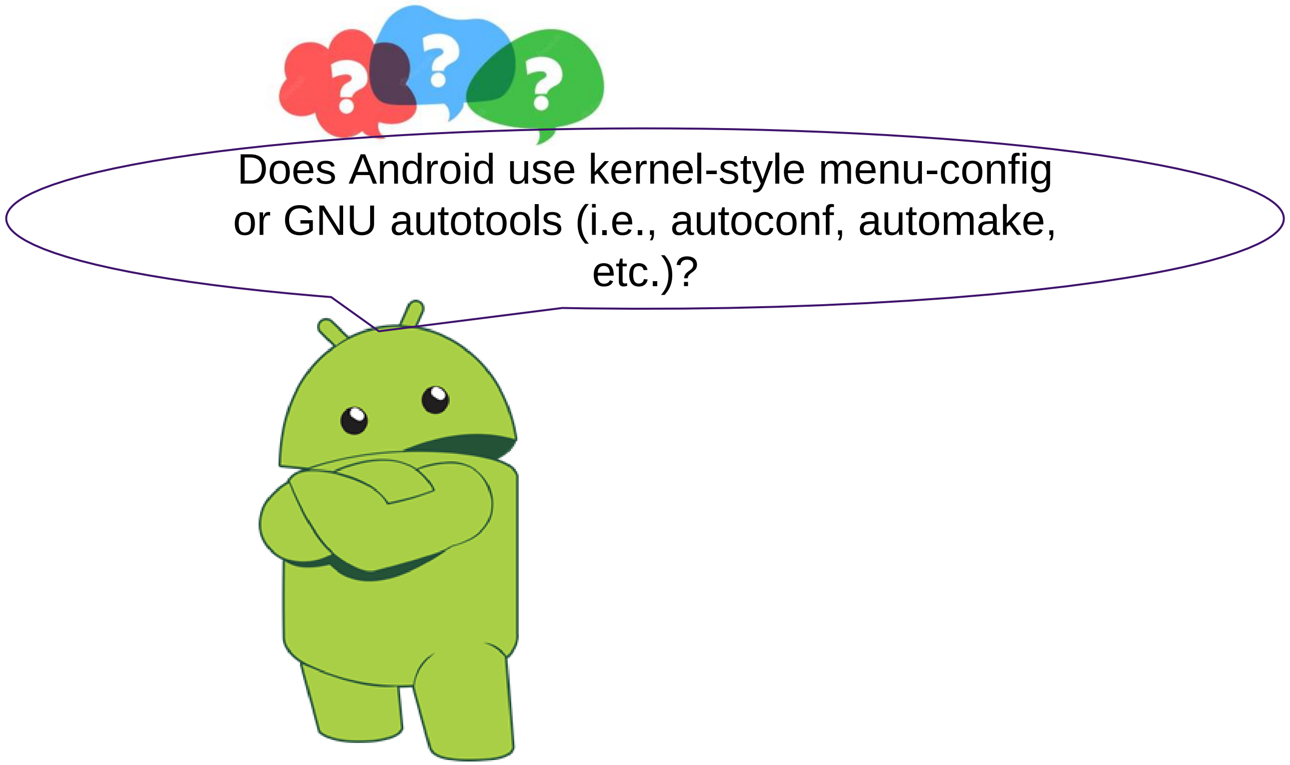
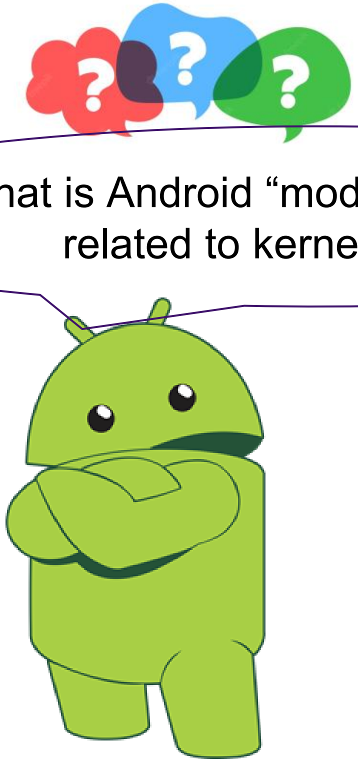
QUIZ (8/10)


Does Android use kernel-style menu-config or GNU autotools (i.e., autoconf, automake, etc.)?

QUIZ (9/10)



What is Android “module”? Is “module” related to kernel “module”?

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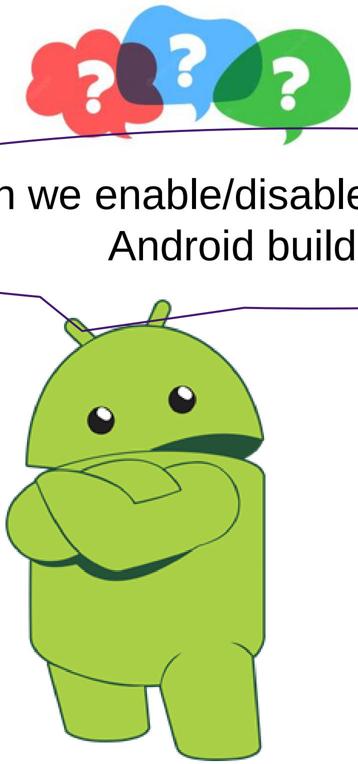
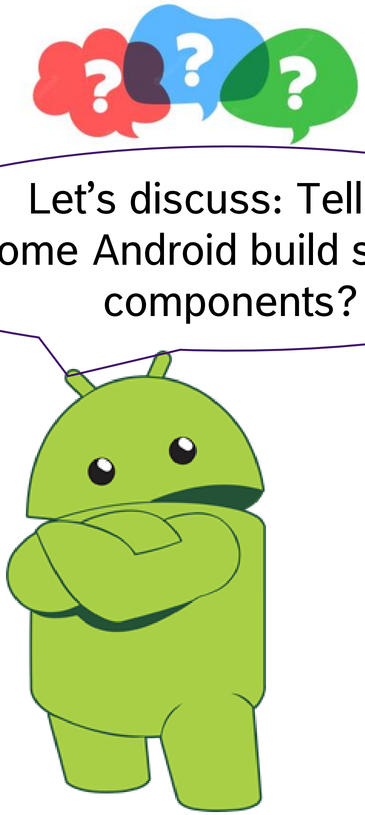
QUIZ (10/10)



Can we enable/disable some features in Android build system?

Group working



Let’s discuss: Tell me some Android build system components?

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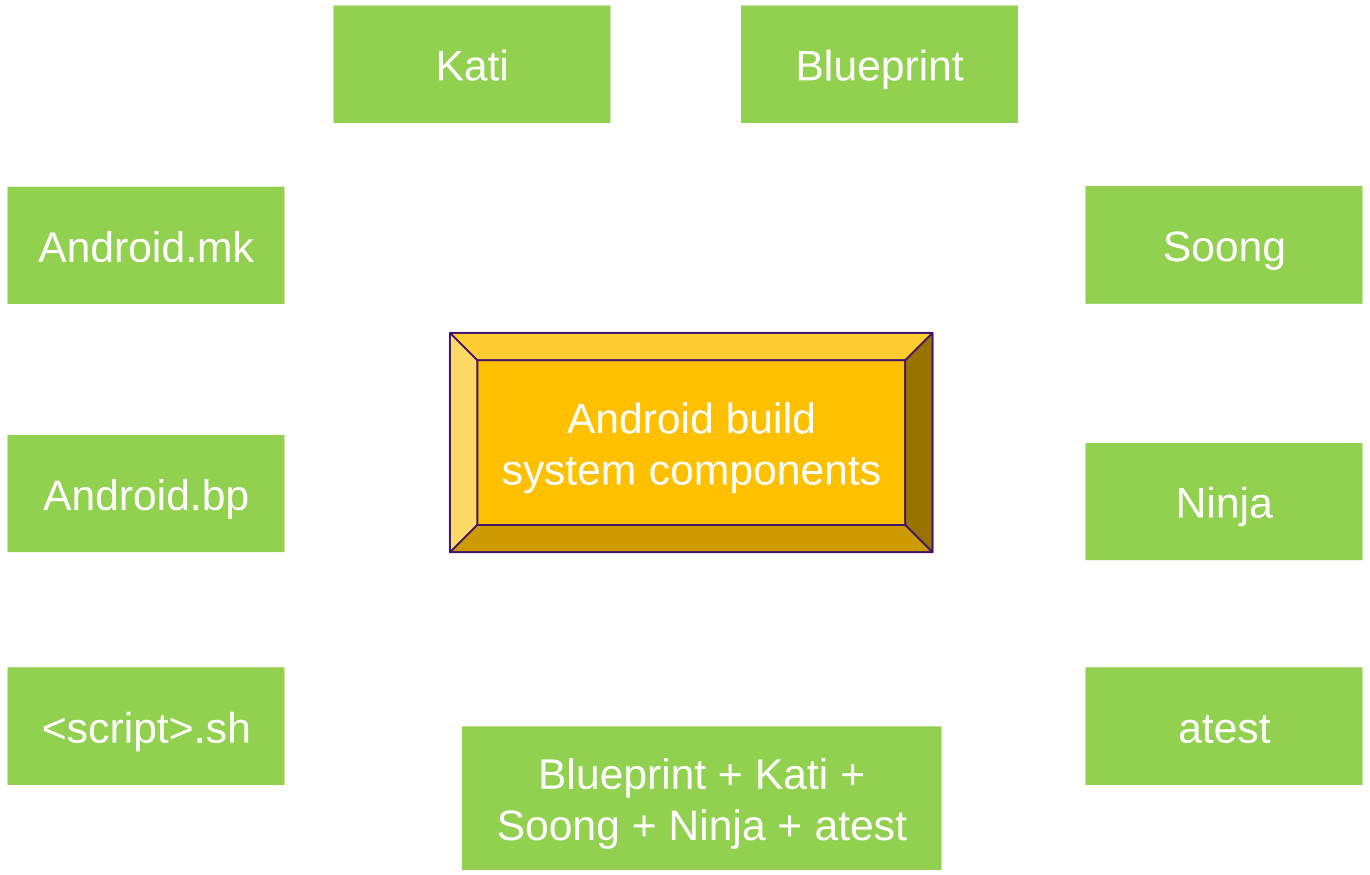
High level components


Kati
Blueprint
Android.mk
Soong
Android build system components
Android.bp
Ninja
<script>.sh
atest
Blueprint + Kati + Soong + Ninja + atest

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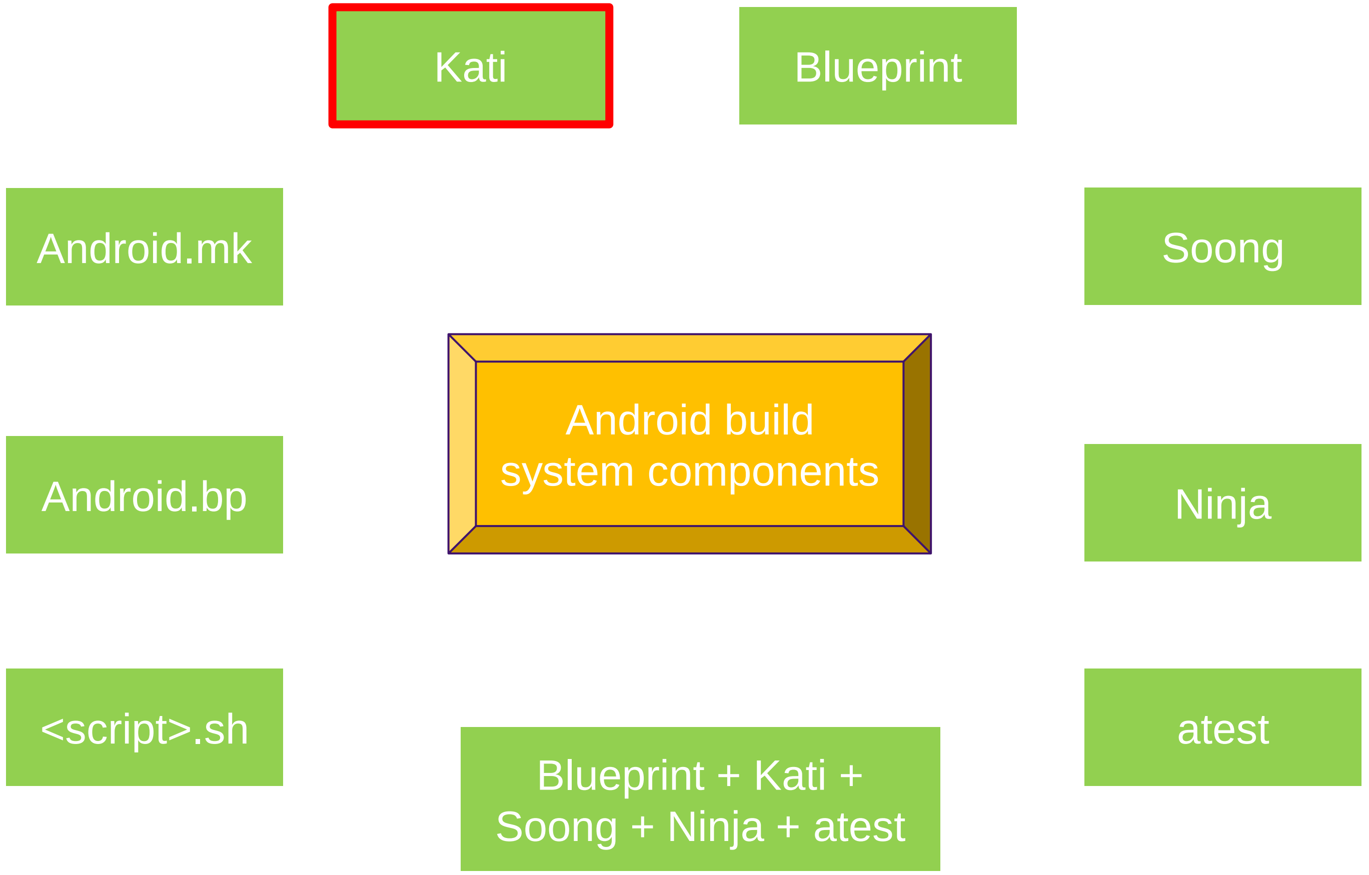
High level components

- Make-compatible front-end.
- Encodes build logic in **.mk** scripts.
- Declares buildable units in Android.mk.
- Generates Ninja file directly.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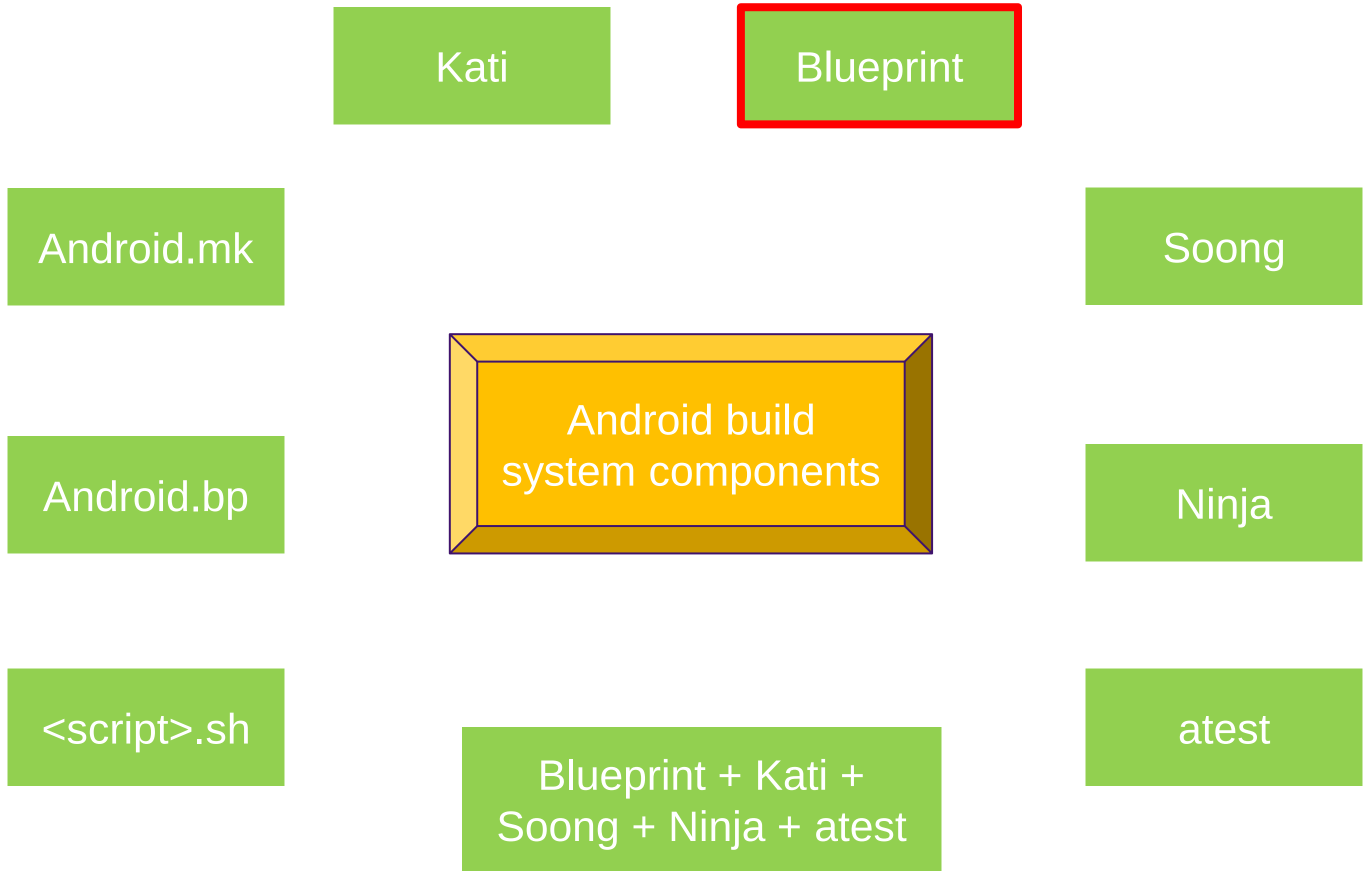
High level components

- Build definition syntax.
- Build syntax parser.
- Internal data structures like Modules/Variations/Context/Scope.
- Ninja file generator.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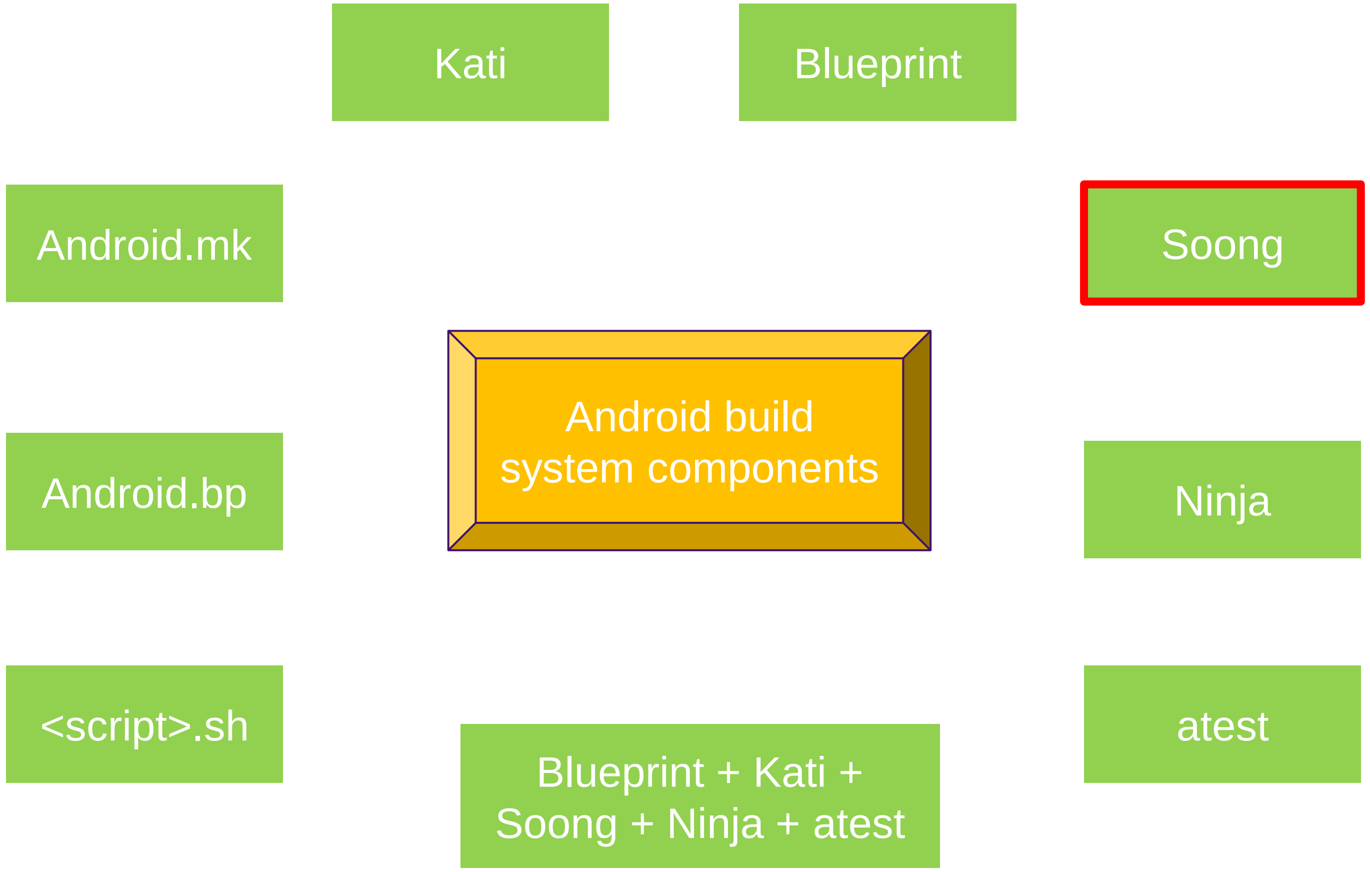
High level components

- Bazel-like front-end.
- Encodes build logic in Go.
- Declares build units in Android.bp, parsed by Blueprint.
- Uses Blueprint to generate Ninja file.
- Generates a **.mk** file with prebuilt module stubs to Kati.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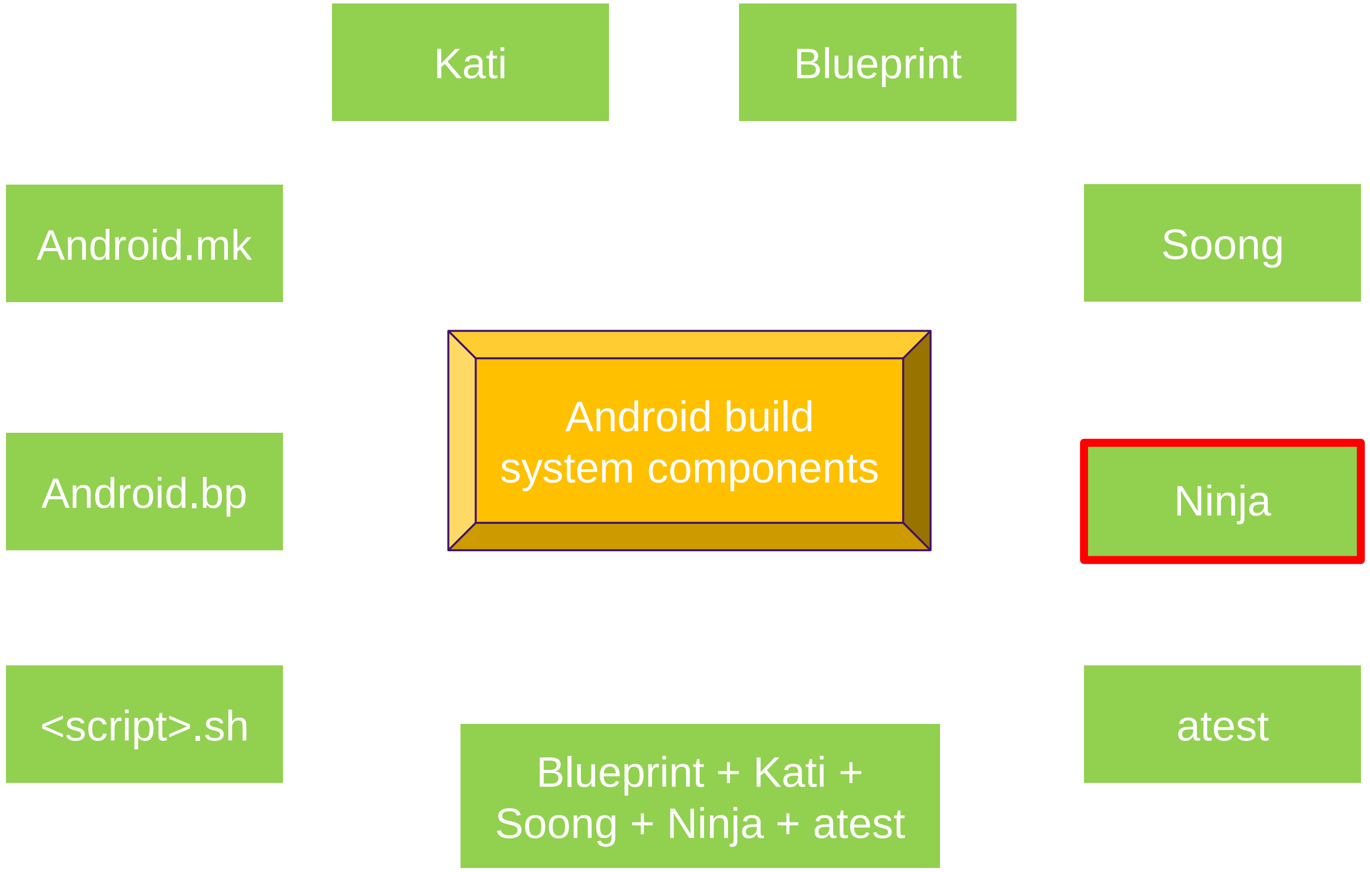
High level components

- Serialized command line action graph executor.
- Executes Ninja graph generated from Kati and Soong.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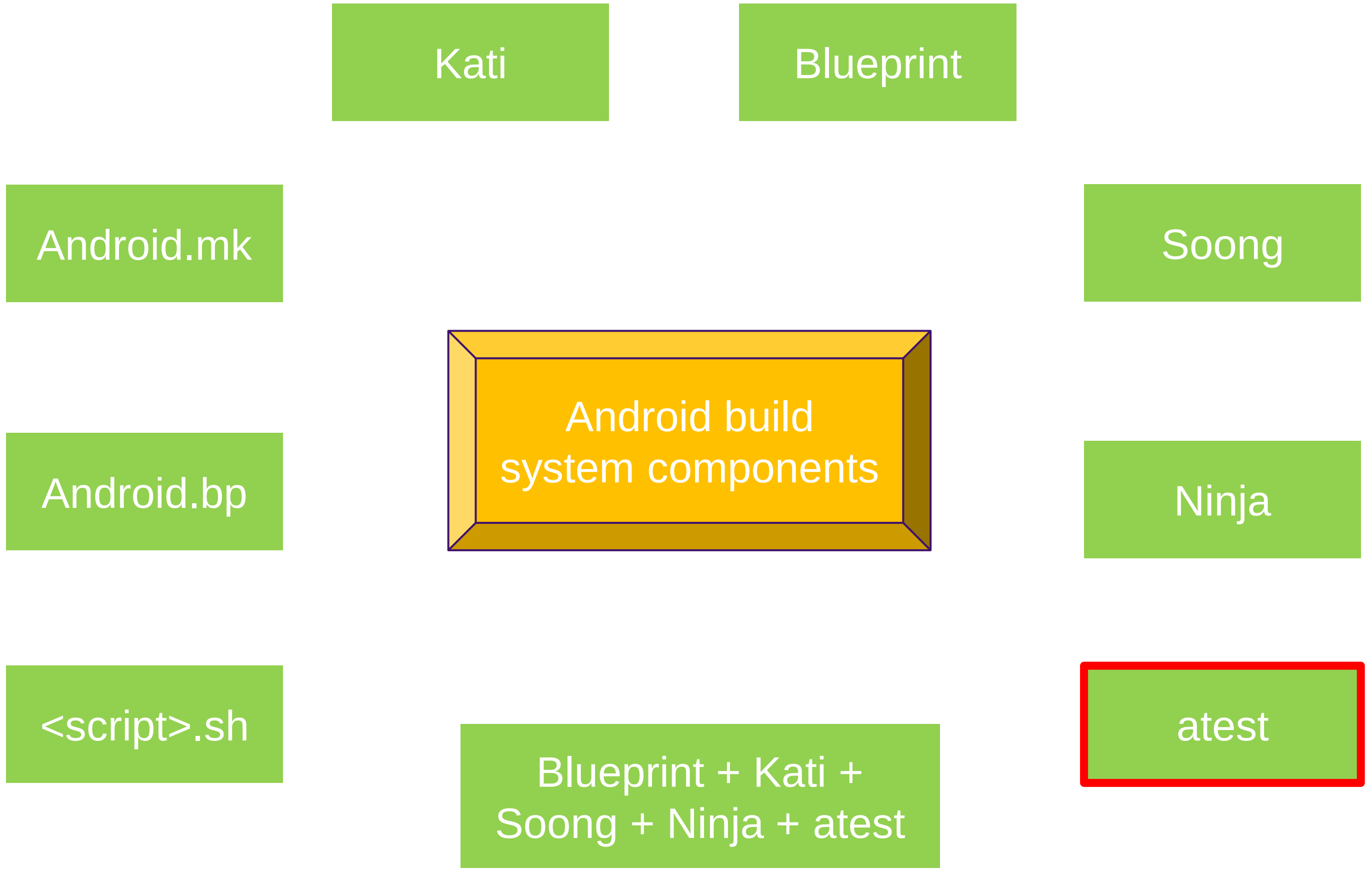
High level components

- Test executor and orchestrator.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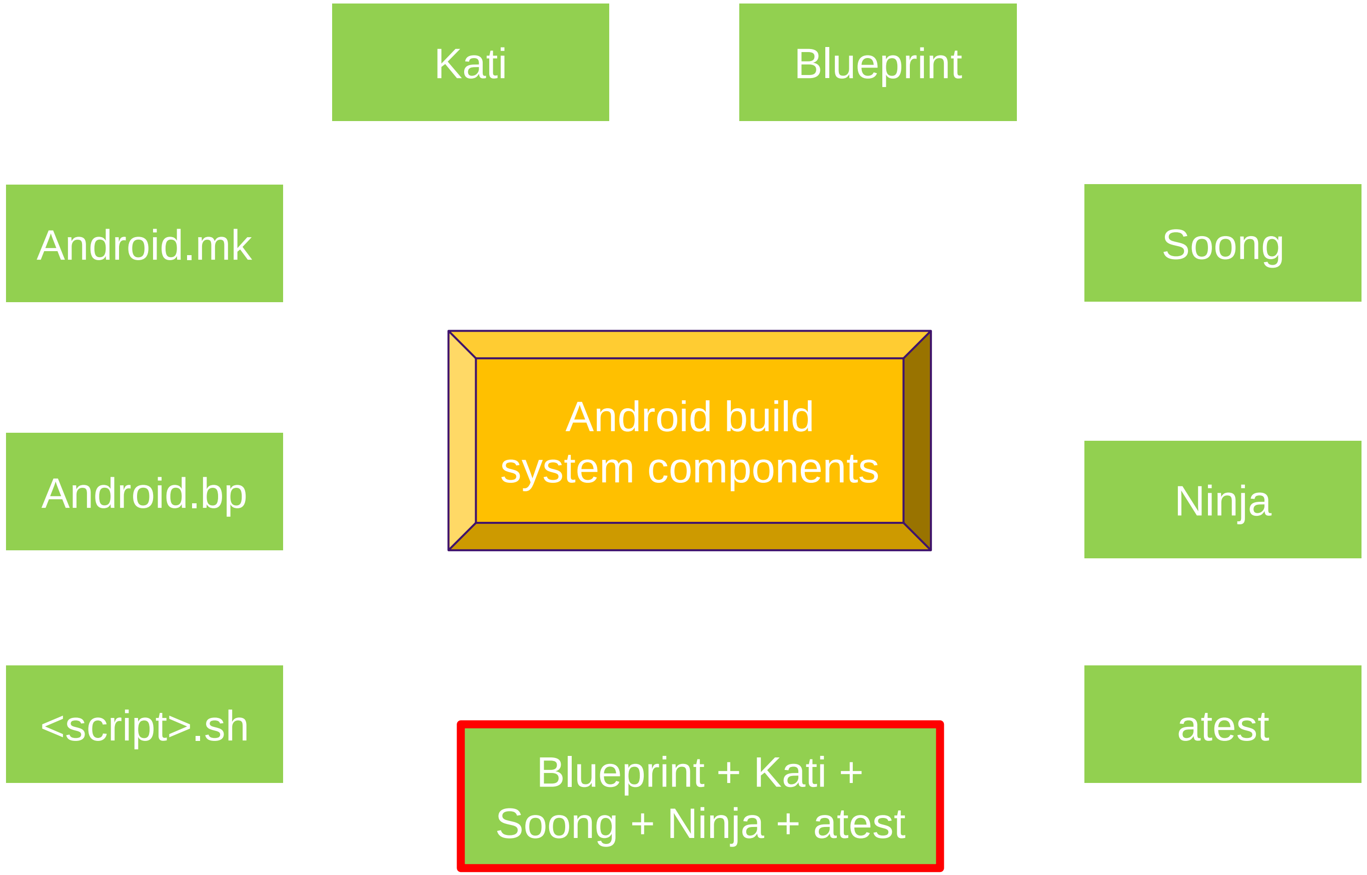
High level components

- The entire build pipeline for Android.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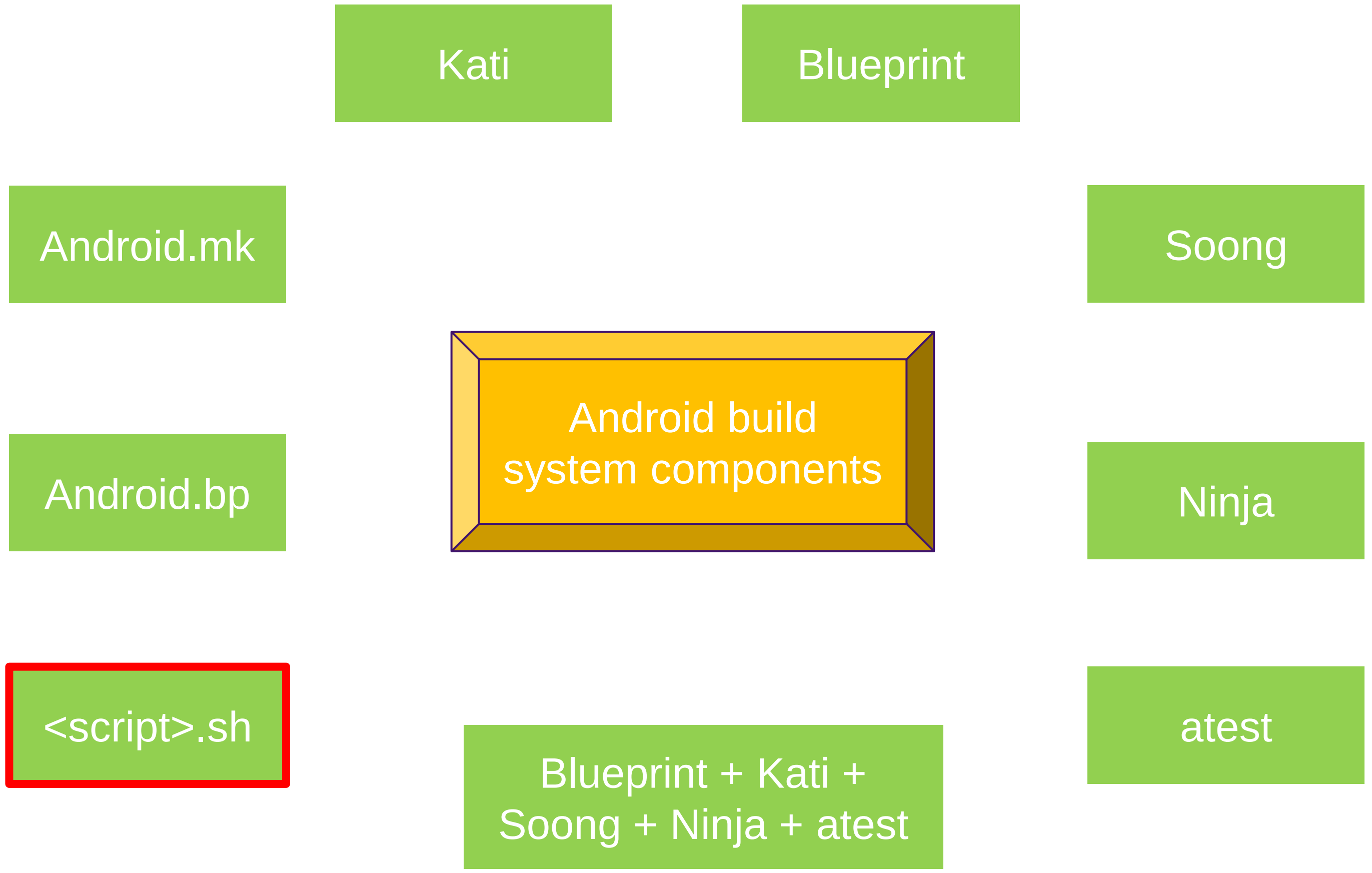
High level components

- Running arbitrary scripts in AOSP.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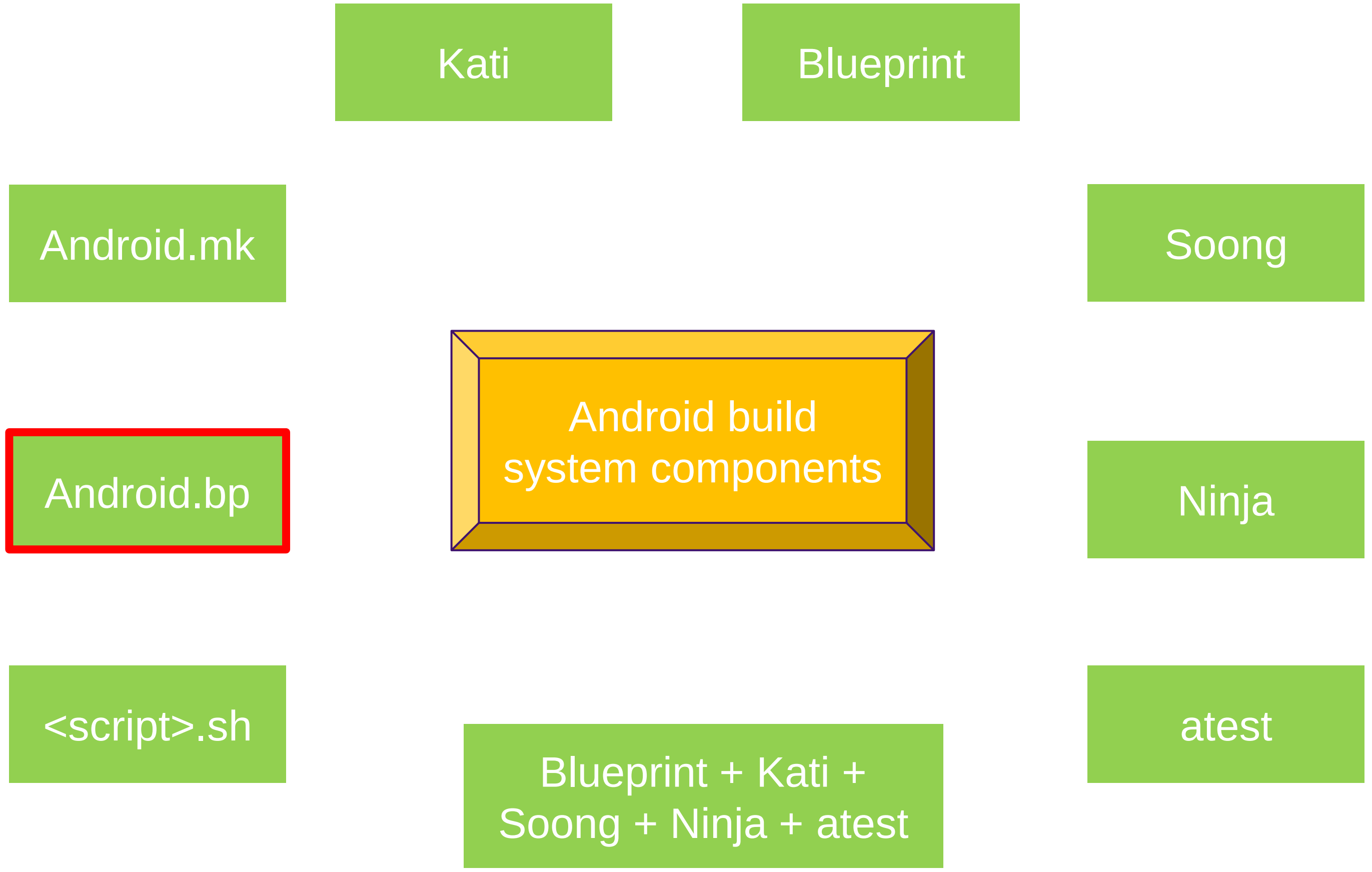
High level components

- Build definition file for Soong.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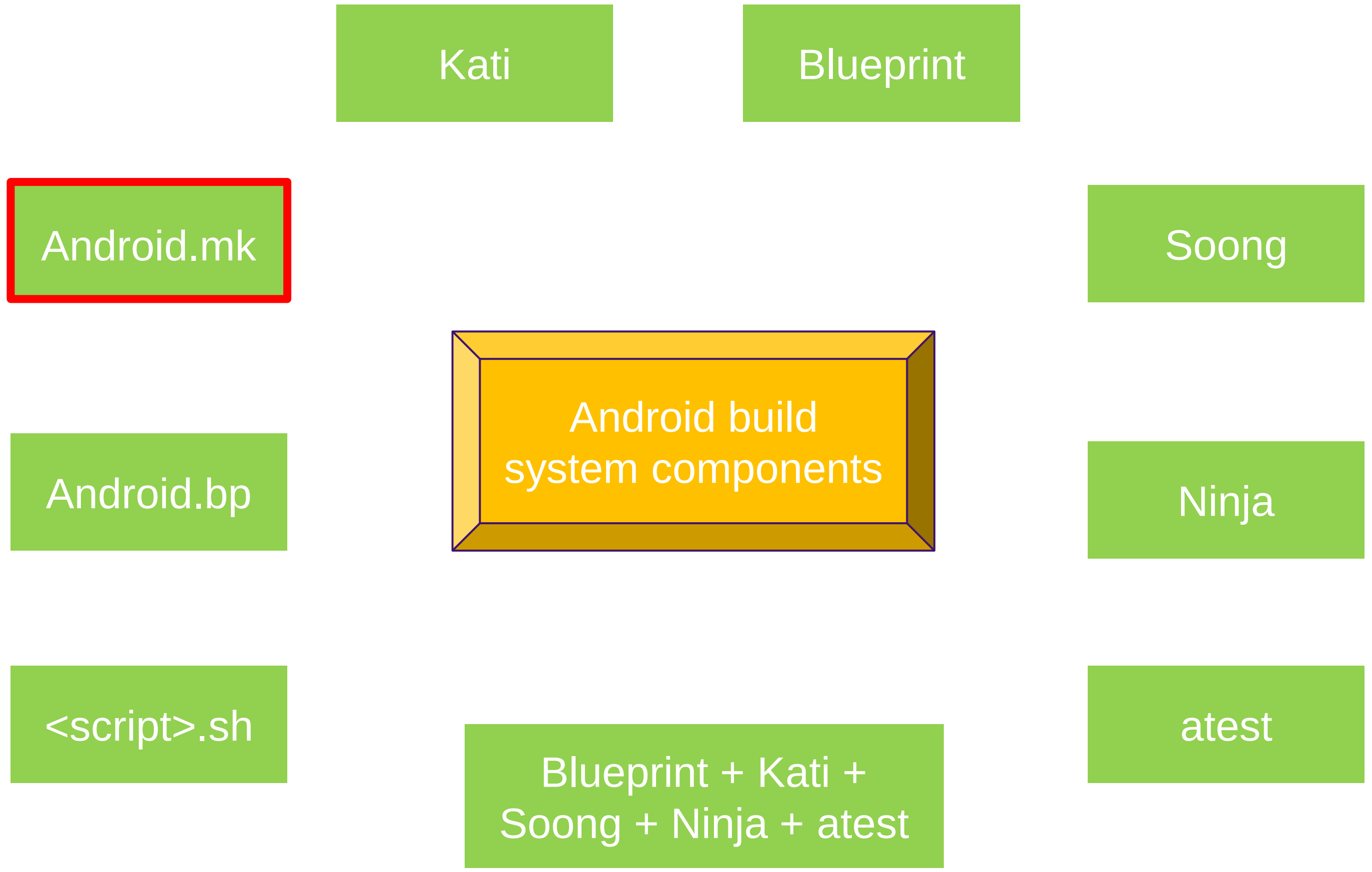
High level components

- Build definition file for Kati.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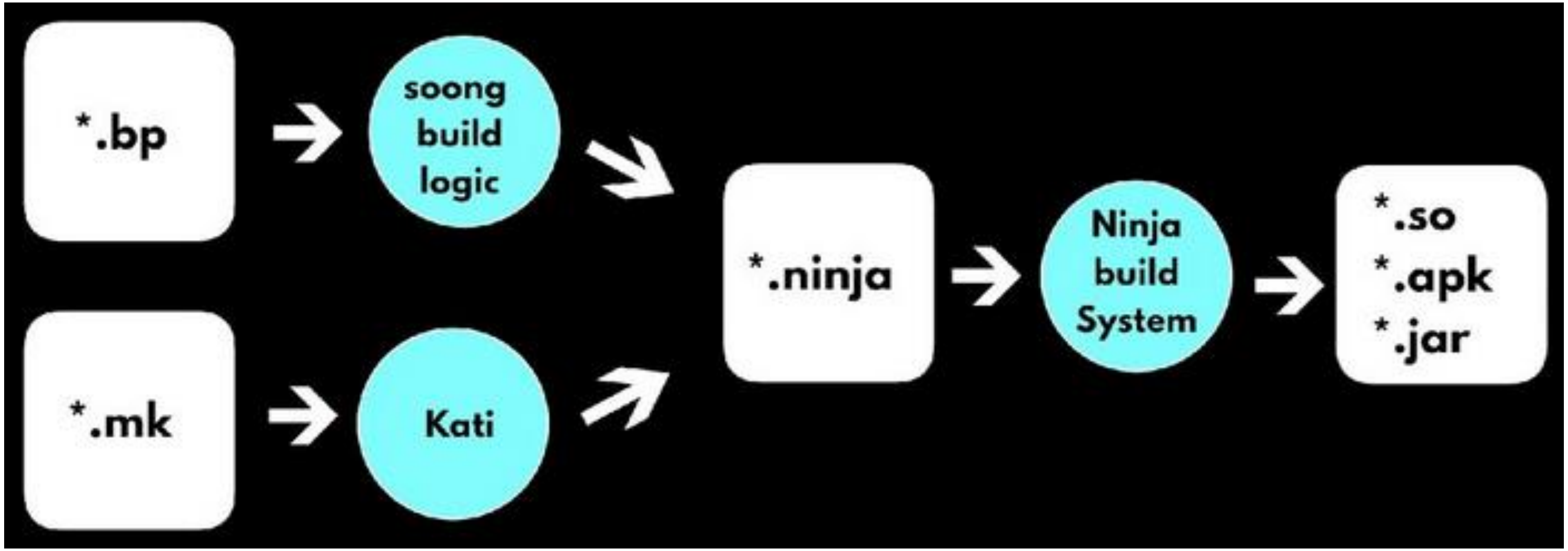
Communication between components



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Communication between components

1. **Kati product configuration** generates **config variables** (**config.mk**, **AndroidProducts.mk**)
2. **Kati** generates **build actions** in Ninja files (**main.mk, Android.mk** files).
3. **Kati** generates **packaging actions** in Ninja files (**packaging.mk** file).
4. **Kati** generates **cleaning actions** in Ninja files (**cleanbuild.mk**, **CleanSpec.mk** files).
5. **soong_build (and Blueprint)** generates **build actions** (**Android.bp**, Blueprints files).

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Communication between components

6. **Ninja** execute **actions** from **Kati-build**, **Kati-package** and **soong_build**
7. **Bazel**, the next generation of the entire build system, start as a **Ninja executor drop-in replacement**
8. **soong_ui** orchestrates **all of the above**, and with auxiliary tools like **finder**, **path_interposer**, **soong_env**, **minibp** and **bpglob**.

- **Note:**
  - The current build system architecture **primarily uses files as the medium for inter-process communication** (IPC), with one known case of unix socket communication (e.g. path_interposer), and a fifo between Ninja and soong_ui for the Protobuf stream for build status reporting.

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Component order

- The build system components run in the following order, orchestrated by soong_ui:

  1. **soong_ui** bootstraps **itself** with **microfactory** (go build replacement) and **launches**.
  2. **soong_ui** runs **auxiliary tools** to aggregate files into **filelists**, for **Android.mk**, **Android.bp**, **AndroidProducts.mk** and **several others**.
  3. **soong_ui** runs **Kati-config** with the **config.mk** entry point.

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Component order

- The build system components run in the following order, orchestrated by soong_ui:

4. **soong_ui** orchestrates **3 Blueprint/Soong phases** to generate the main **out/soong/build.ninja** file: **minibootstrap**, **bootstrap**, and **primary**:
   a) **Minibootstrap phase** uses **Blueprint/Microfactory** to build itself (minibp) so that **Android.bp and Blueprint files can be used to define Soong**.

   b) **Bootstrap phase** runs **Ninja** on a **build.ninja** file that runs minibp to read all **Android.bp** files across the source tree that describes Soong and plugins, and builds soong_build.

   c) **Primary phase** runs **Ninja** on a **build.ninja** file that runs soong_build to generate the final **out/soong/build.ninja** file.

   d) **soong_build** also **runs its own tests** alongside generating **out/soong/build.ninja**, which can be skipped with the **--skip-soong-tests** argument.

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Component order

- The build system components run in the following order, orchestrated by soong_ui:

5. **soong_ui** runs **Kati-cleanspec** with the **cleanbuild.mk** entry point.
6. **soong_ui** runs **Kati-build** to generate a Ninja file, with the **main.mk** entry point.
7. **soong_ui** runs **Kati-package** to generate a Ninja file, with the **packaging/main.mk** entry point.
8. **soong_ui** generates **a Ninja file** to combine above **Ninja files**.
9. **soong_ui** runs **either Ninja or Bazel to execute the build**, with the **combined Ninja file** as entry point.

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soong_ui

- **soong_ui** is primarily responsible for **orchestrating the build**, **cleaning the build environment, and running auxiliary tools**.
- These tools (**minibp**, **microfactory**) can bootstrap other tools (**soong_build**), aggregate file lists (**finder.go**), improve hermeticity (**path_interposer, nsjail**) or perform checks against the environment (soong_env).
- **soong_ui** uses **finder.go** to generate **<filename>.list** files for other tools.
- For example, it generates **Android.mk.list** for Kati-build, **AndroidProducts.mk.list** for Kati-config, and **Android.bp.list** for soong_build.

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soong_ui

- **soong_ui** uses **path_interposer** to prepare an hermetic **$PATH** with runtime checks against allowlisted system tools.
  - The **$PATH** contains these system tools with checked-in prebuilts, and uses path_interposer to intercept calls and error out whenever non-allowlisted tools are used (see out/.path for directory of intercepted tool symlinks).
- **soong_ui** generates **a Kati suffix** to ensure that Kati-generated files are regenerated if inputs to Kati have changed between builds.

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soong_ui

- **soong_ui** calls **Soong and Kati** to generate **Ninja files**, and eventually creates **another Ninja file** (**out/combined-<product>.ninja**) to **combine the others, and executes either Ninja or Bazel to complete the build**.
- **soong_ui** sets **up the sandbox and environment** for the **Ninja/Bazel process**.

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Kati-config

- As a product configuration tool, **soong_ui** runs **Kati-config** in **--dumpvars-mode** to dump the values of specified Make variables at the end of an evaluation, with **build/make/core/config.mk** as the entry point.
- During this phase, **Kati-config** eventually evaluates **soong_config.mk** to generate the **soong.variables JSON file**.
- This way, **Kati-config** can communicate **product configuration to soong_build**, as **soong_build** parses the **dumped variables** from **the JSON** on startup, and stores them into an **in-memory Config object**

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Kati-config

- To communicate dexpreopt variables to soong_build, **dexpreopt.config** is also generated as **a $(shell) action** and read by **soong_build** in a similar way as **Kati-config** evaluates **dex_preopt_config.mk** included in **soong_config.mk**.
- **soong_ui** sets up **a KatiReader** to monitor **Kati-config's stdout/err** for **UI reporting and error handling purposes**.

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soong_build

- **soong_build's** primary role is to **evaluate all Android.bp files**, **run a series of mutators**, and **generate out/soong/build.ninja file**.

- **soong_build** communicates with **Kati-build** by generating **Make Vars** and running the **AndroidMk singleton** to **generate .mk files** in the output directory (**out/soong/{Android, late, make_vars}-<product>.mk**).
  - **Android-<product>.mk** contains **Soong modules** as **Make modules** so Make modules can depend on **Soong modules**.
  - **make_vars-<product>.mk** contains **Make variables** for **Kati-build**, exported from **Soong modules**. There are also **checks built into this .mk file to ensure that if a duplicate Make variable of the same name comes from another source**, the Soong and Make variable values are identical.

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- **soong_build** communicates with **Kati-build** by generating **Make Vars** and running the **AndroidMk singleton** to **generate .mk files** in the output directory (**out/soong/{Android, late, make_vars}-<product>.mk**).
  - **late-<product>.mk** contains **Make variables** that are not read while **Kati-build** parses **the Android.mk** file. (Late variables):
    - **soong_ui** invokes **Kati** to parse **make_vars .mk** file earlier than the **Android.mk files**, and **late.mk** after parsing the **Android.mk files**.

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soong_build

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  - **late-<product>.mk** contains **Make variables** that are not read while **Kati-build** parses **the Android.mk** file. (Late variables):
    - **late.mk** is used to **define phony rules** to take advantage of **Make's ability to add extra dependencies to an existing rule**. **late.mk** is not strictly necessary to make this happen at this moment, since **late.mk rules** don't currently depend **on any variables** defined during **Android.mk processing** (e.g. ALL_MODULES$(module).INSTALLED).

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Kati-build / Kati-package

- **Kati-build's primary role** is to **evaluate all Android.mk files** with **build/make/core/main.mk** as entry point, and **generate out/build-<product>.ninja**.
- **It** also **generates cleanspec.ninja** for **the product, containing statements** on how to remove stale output files.
- **Kati-build's primary role** is to **evaluate all packaging .mk files** with **build/make/packaging/main.mk** as entry point, including **build/make/packaging/distdir.mk** for dist-for-goals calls, and **generate out/package-<product>.ninja.**

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Kati-build / Kati-package

- **Kati-build/Kati-package's stdout/stderr** is **monitored** by **soong_ui's KatiReader** to UI and error handling.
- **Kati-build/Kati-package generates Ninja files. They** also **generate out/ninja-<product>.sh and out/env-<product>.sh.**
- These scripts are wrappers for **soong_ui** to **execute Ninja** with the correct **Ninja files**, in **a controlled environment**.

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Ninja

- **Ninja executes files** from **Kati-build, Kati-package, soong_build and other bootstrapping tools like Blueprint**
- After that, **it writes** to **a fifo** in a proto front end that soong_ui monitors with NinjaReader.
- **NinjaReader ensures** that the **user interface for Ninja progress is consistent** with the rest of the build.

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Bazel

- **soong_build serializes information** about converted modules to **BUILD/bzl files on disk**.
- **soong_build** then **consumes information** about these targets from Bazel **by directly calling the Bazel client to issue cquery calls about these targets**.

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