1. Runtime Verification

Runtime verification:
A technique that detects errors in programs, based on:
- Providing a specification for the program.
- Observing the behavior of the running program.
- Detecting (and reacting to) any violations of the specified behavior.

Some research challenges:
- Better formalisms and specification languages.
- Reducing run-time overhead:
  - Optimizing program instrumentation.
  - Combination with static analysis.

Future work:
- Improving Ciao program specification.
- Code reuse (patterns, templates, etc.).
- Better formalisms and specification languages.
- Optimizing program instrumentation.
- Detecting (and reacting to) any violations of the specified behavior.

3. Specification for HO Predicates? We Can Do It!

Currently in most (C)LP systems not much can be specified about the predicate arguments of higher-order predicates:

```
% Predicate assertion format in Ciao:
% :- pred P : Precondition => Postcondition.
% :- pred min(X,Y,Cmp,M) : callable(Cmp).
```

We introduce the notion of "predicate properties (predprops)" to apply recursively the argument language to arguments that contain predicates:

```
:- comparator(Cmp) {
  :- pred Cmp(Res,X,Y) : num(M), num(N) => between(-1,1,Res).
}

:- pred min(X,Y,Cmp,M) : callable(Cmp).
```

4. Instrumenting Programs

During the compilation the initial program with specification:

```
5: pred min(X,Y,Cmp,M) : callable(Cmp).
```

is transformed into program with checks, that trigger on each predicate call and exit:

```
4: pred Head : Pre, Post.
Head :- Body_1.
Head :- Body_2.
```

While the initial program flow is preserved.

```
5: pred Head : prec_chck, NewHead.
NewHead :- Body_1.
NewHead :- Body_2.
```

5. How it works

Work in progress:
- Improving Ciao program instrumentation.
- Reducing run-time check overhead by caching checks.

Future work:
- Extend static analysis-based check simplification during compilation to the higher-order case.
- Reducing overhead for higher-order property checks.

7. Quick Links

- ciao-lang.org
- clip.dia.fi.upm.es
- software.imdea.org (publications)