

## Review

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# Summary

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## **You've been introduced to a variety of tools**

- with hints to apply and use the tools effectively

## **Tools provide complementary capabilities**

- computational kernel & processor analyses
- communication/synchronization analyses
- load-balance, scheduling, scaling, ...

## **Tools are designed with various trade-offs**

- general-purpose versus specialized
- platform-specific versus agnostic
- simple/basic versus complex/powerful

## Tool selection

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### **Which tools you use and when you use them likely to depend on the situation**

- which are available on (or for) your computer system
- which support your programming paradigms and languages
- which you are familiar (comfortable) with using
- which type of issue you suspect
- which question you want to have answered

**Being aware of (potentially) available tools and their capabilities can help finding the most appropriate tools**

## Workflow (getting started)

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### First ensure that the parallel application runs correctly

- no-one will care how quickly you can get invalid answers or produce a set of core-files
- parallel debuggers like *DDT* or *STAT* help isolate anomalies
- correctness checking tools such as **MUST**/*ARCHER* can identify other issues (that might not cause problems right now, but will eventually)
  - e.g., race conditions, invalid/non-compliant usage

### Best to start with an overview of execution performance

- fraction of time spent in computation vs. communication/synchronization vs. I/O
- which sections of the application/library code are most costly
- Example parallel profilers: **Score-P + Cube/ParaProf, TAU, MAQAO, MAP**

### and how it changes with scale or different configurations

- processes vs threads, mappings, bindings

## Workflow (communication/synchronization)

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**Communication issues generally apply to every computer system (to different extents) and typically grow with the number of processes/threads**

- *Weak scaling*: fixed computation per thread, and perhaps fixed localities, but increasingly distributed
- *Strong scaling*: constant total computation, increasingly divided amongst threads, while communication grows
- Collective communication (particularly of type “all-to-all”) result in increasing data movement
- Synchronizations of larger groups are increasingly costly
- Load-balancing becomes increasingly challenging, and imbalances more expensive
  - generally manifests as waiting time at subsequent collective operations



## Workflow (wasted waiting time)

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### Waiting times are difficult to determine in basic profiles

- Part of the time each process/thread spends in communication & synchronization operations may be wasted waiting time
- Need to correlate event times between processes/threads
  - Post-mortem event trace analysis avoids interference and provides a complete history
  - **Scalasca** automates trace analysis and ensures waiting times are completely quantified
  - **Vampir** allows interactive exploration and detailed examination of reasons for inefficiencies
  - **BSC Tools (Paraver/Dimemas/Extrac)** support comprehensive detailed trace analyses

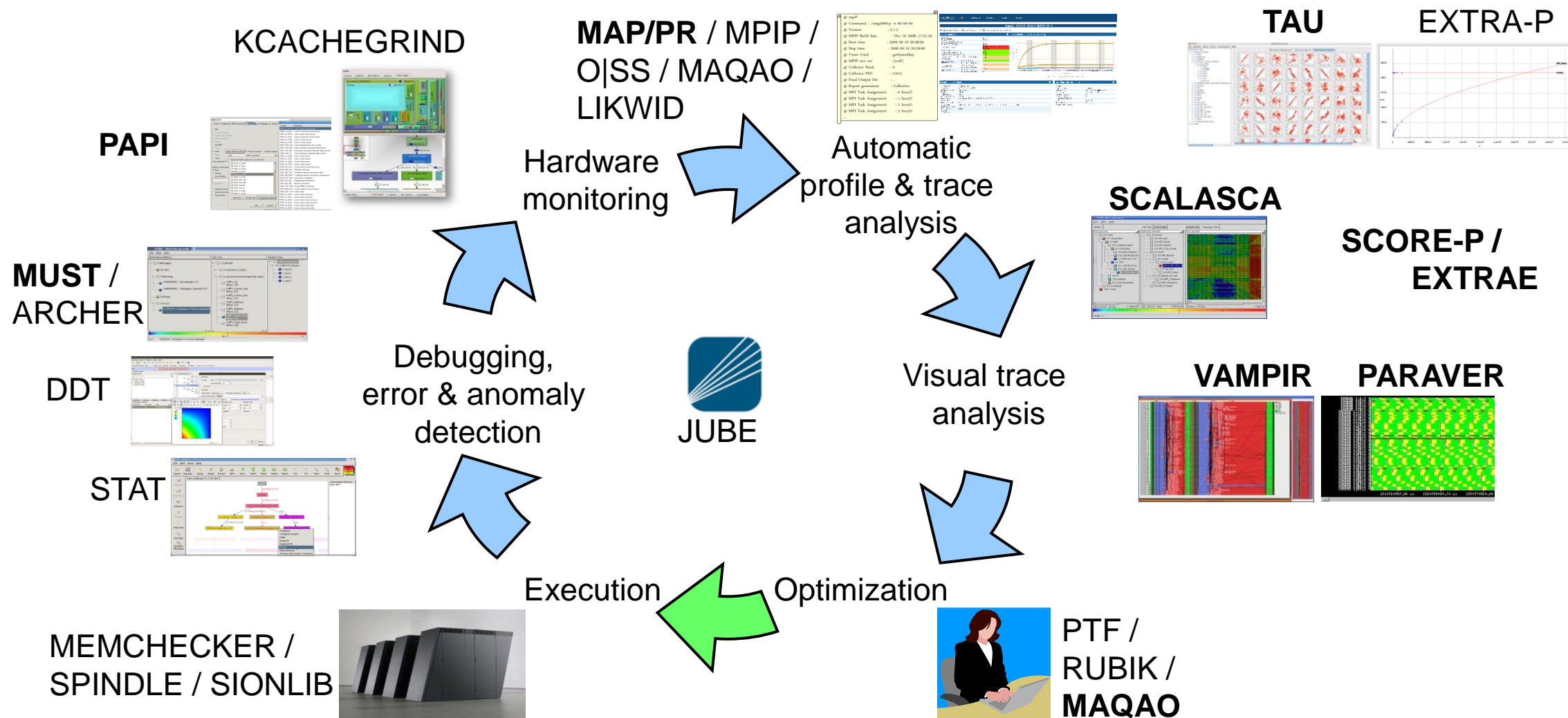
## Workflow (core computation)

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### Effective computation within processors/cores is also vital

- Optimized libraries may already be available
- Optimizing compilers can also do a lot
  - provided the code is clearly written and not too complex
  - appropriate directives and other hints can also help
- Processor hardware counters can also provide insight
  - although hardware-specific interpretation required
  - can be accessed with **PAPI** or *LIKWID*
- Cache analysis can be investigated with *Callgrind*
- Optimised code generation for x86 can be investigated with *MAQAO*
- Tools available from processor and system vendors help navigate and interpret processor-specific performance issues

# Technologies and their integration





## Evaluation / Feedback

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- Please also complete the online VI-HPS workshop/tools evaluation form
  - provides valuable feedback
    - to improve future workshops and training
    - to tools developers for improving their tools and training material
  - can be anonymous if desired
  - <https://forms.gle/AXKo6QPwBxLUix3b6>
- Tools support queries and bug reports are also welcome
  - should be submitted to respective support mailing lists
  - and/or sometimes to local technical support staff

## Further information

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### Website

- Introductory information about the VI-HPS portfolio of tools for high-productivity parallel application development
  - VI-HPS Tools Guide
  - links to individual tools sites for details and download
- Training material
  - tutorial slides
  - latest ISO image of VI-HPS Linux DVD with productivity tools
  - user guides and reference manuals for tools
- News of upcoming events
  - tutorials and workshops
  - mailing-list sign-up for announcements

<http://www.vi-hps.org>