1st International Electronic Conference on Machines and Applications

Defining the Technical Availability of a Production System with Respect to its Complexity

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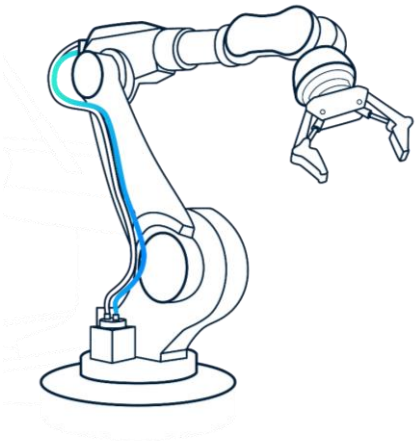
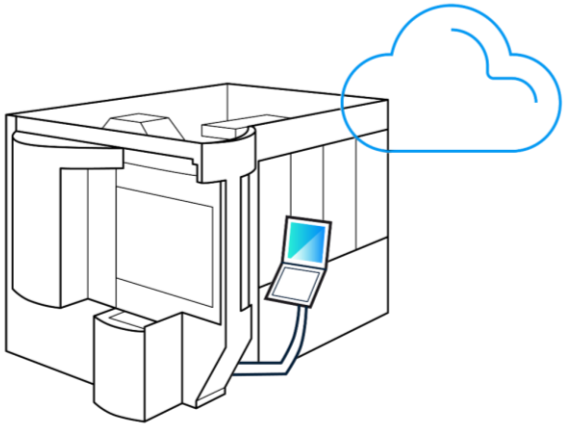
Maintenance in increasingly more complex production systems

Availability as one of the main key figures to assess maintenance success

Maintenance in production systems

- Production systems are becoming increasingly complex
- Maintenance is one of the important factors to influence the efficiency of a production system
- The main focus of maintenance is the availability of production machines
- In an complex production system, the availability of each machine influences the availability of the system in different ways
  - If a machine has redundancies, a machine failure does not impact the production system as much as without redundancies
- If availability is used as a key figure to assess the maintenance success, using the individual machine availability is not sufficient
- The key figure availability needs to reflect the interactions of the machines in the production system





Goal of this publication

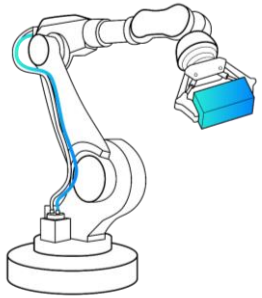
- Reflect different ways to define the availability of a production system
- Compare the main definition based on their performance for different production system
- Recommend a definition for availability of a production system based on its complexity

The two main definitions of availability of a production system

Based on literature review, focusing on maintenance relevant availability

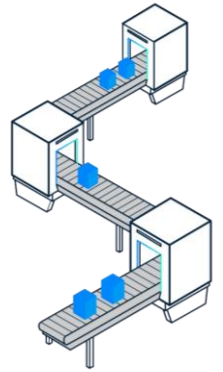
Machine-based availability

- The average of the availability of each machine individual
- The availability of each machine is defined as its actual uptime divided by its planned uptime
- Only direct downtimes due to maintenance relevant machine failures are recorded



Output-based availability

- Actual output of a production system divided by the planned output of the system
- The actual output is only reduced by maintenance relevant production reduction
- Direct downtimes of machines and their influences on the production system are recorded

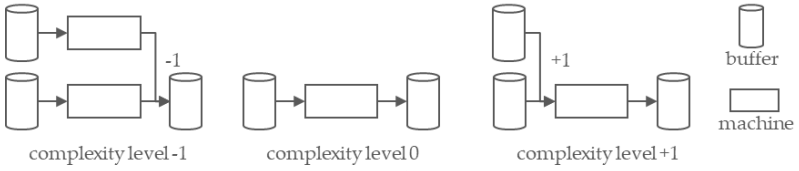


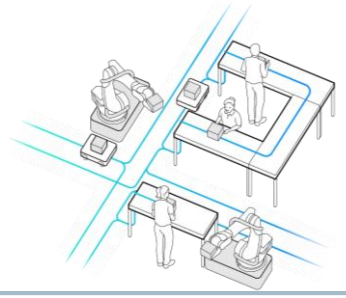
Evaluation of the complexity of production systems

Easy to use key figures in order to compare different production systems, based on literature review

System configuration

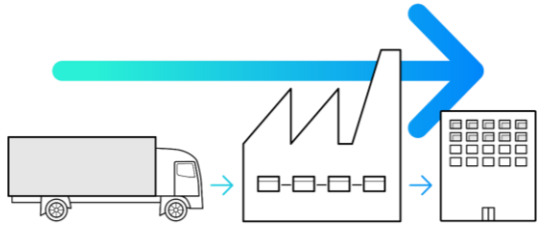
- If two machine are redundant, it makes a production system more robust. If the intermediaries of two machine are needed at the next machine, a failure of one of those can interrupted the production system
- A system without branches is defied at complexity level 0
- Each branch either adds or subtracts one level





(relative) Buffer size

- The buffer sizes between machines influence the complexity
- A system without buffers is much more prone to interference than a system with large buffer sizes
- Relative buffer size of one is defined as the necessary buffer size to get through an average machine failure without negative influences on the production system

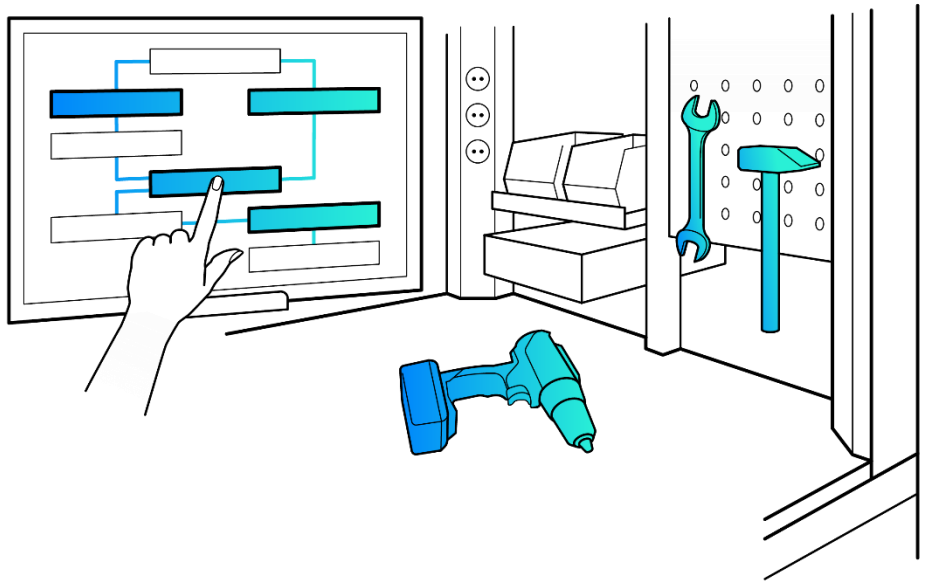


Simulation of different production systems

Event based simulation of production systems with different buffer sizes and complexity levels

Simulation

- Event based simulation using SimPy
- Simulating a 24 / 7 production year using one minute intervals with 24 machines
- The production time of a single machine is 12 minutes, of redundant machines longer
- The buffer sizes between all machines are the same
- The initial buffer level is one half of the buffer size (rounded down)
- Simulation of complexity levels from – 15 to +15
- Simulation of relative buffer sizes up to 12
- 30 simulation run for each combination of buffer size and complexity level

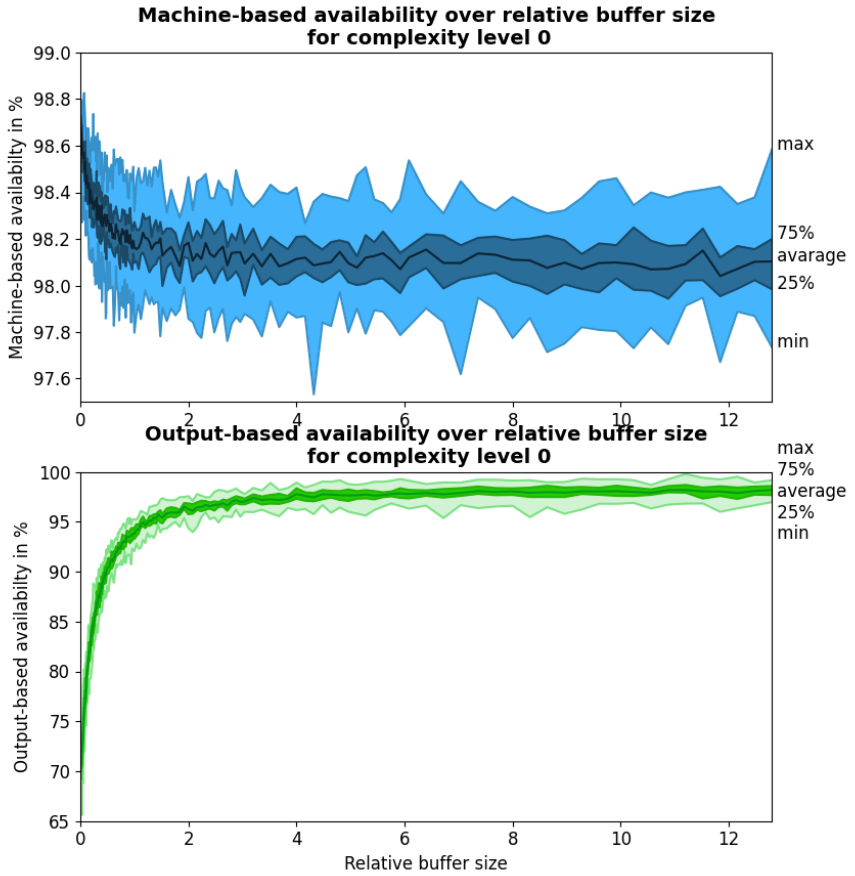


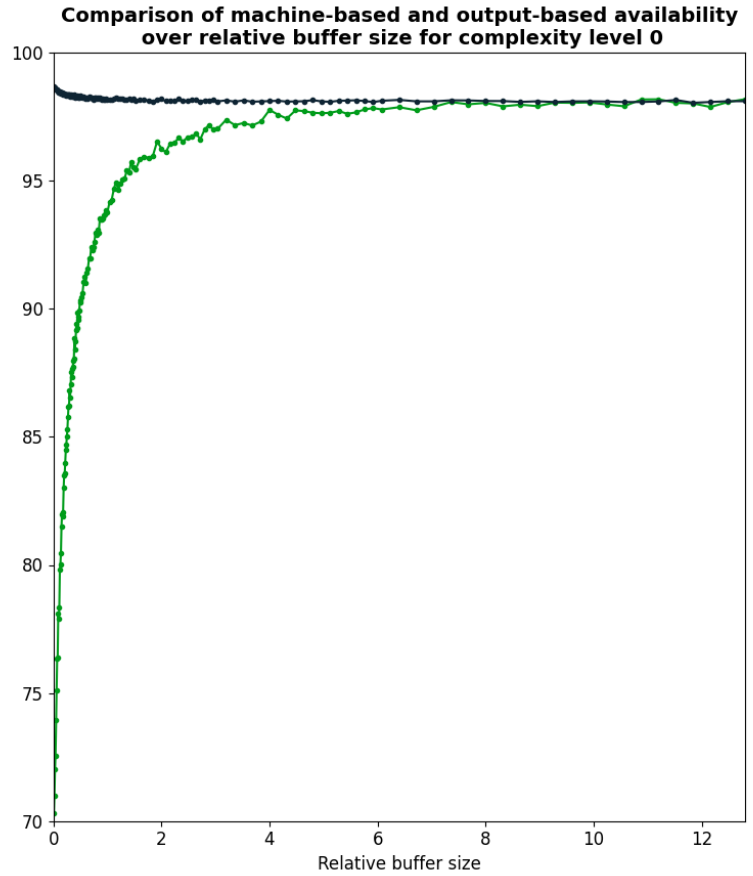
Evaluation of the performance of the two availability key figures

For complexity level 0, over the relative buffer size

Results

- The fluctuations of the results within the 30 simulation runs are manageable
- The machine-based availability lowers with larger buffer sizes
- Compared to the output-based availability it stays about constant
- The output based availability begins at about 70% at actual buffer size one and rises up to the same level as the machine-based availability
- At about a relative buffer size of six, the machine- and output-based availability resemble each other



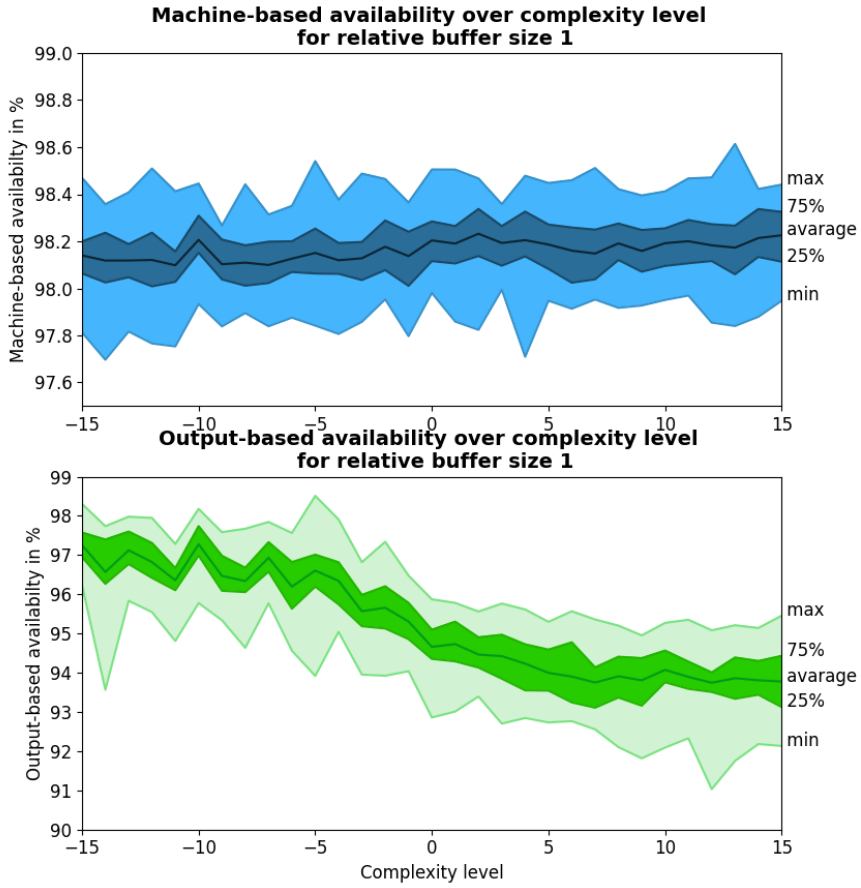


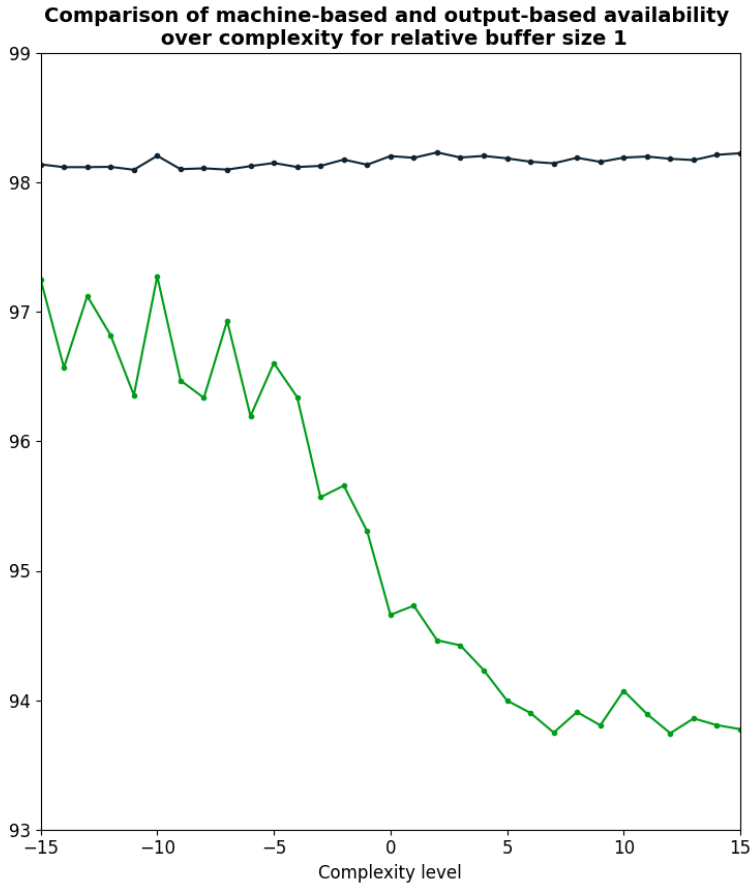
Evaluation of the performance of the two availability key figures

For relative buffer level 1, over the complexity level

Results

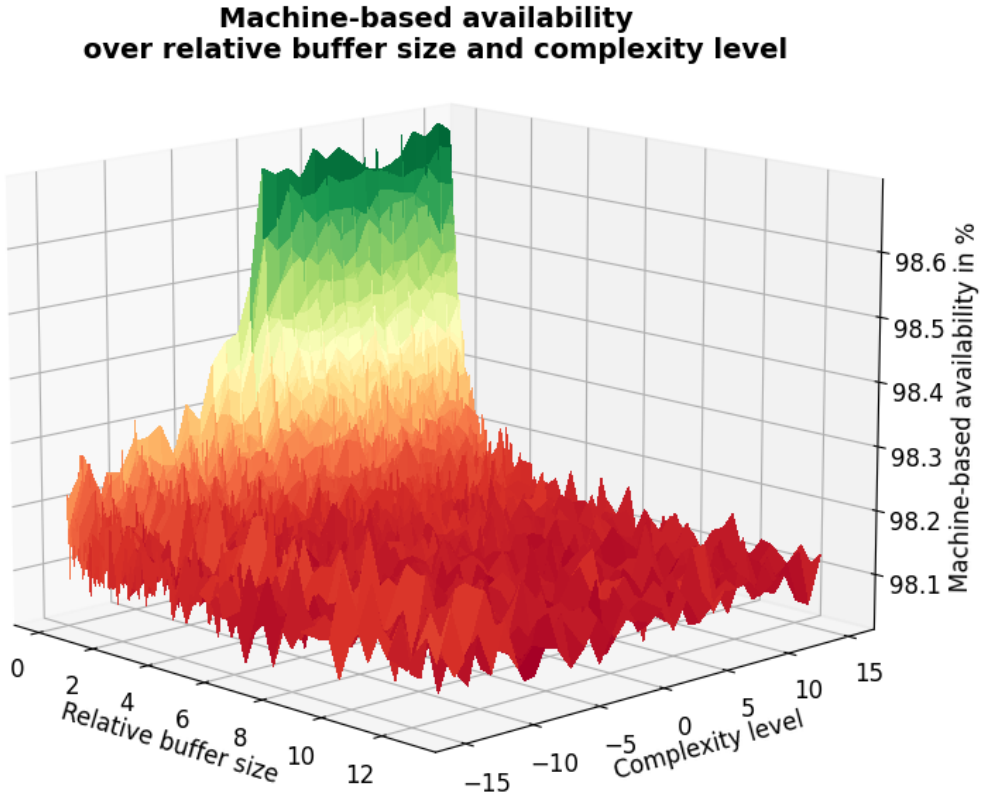
- The fluctuations of the results within the 30 simulation runs are manageable
- Compared to the output-based availability it stays about constant
- The output-based availability begins a little bit lower than the machine-based availability and drops to about 94% within more complex systems
- The output based availability does not drop further, even when the complexity level increases after about complexity level 6

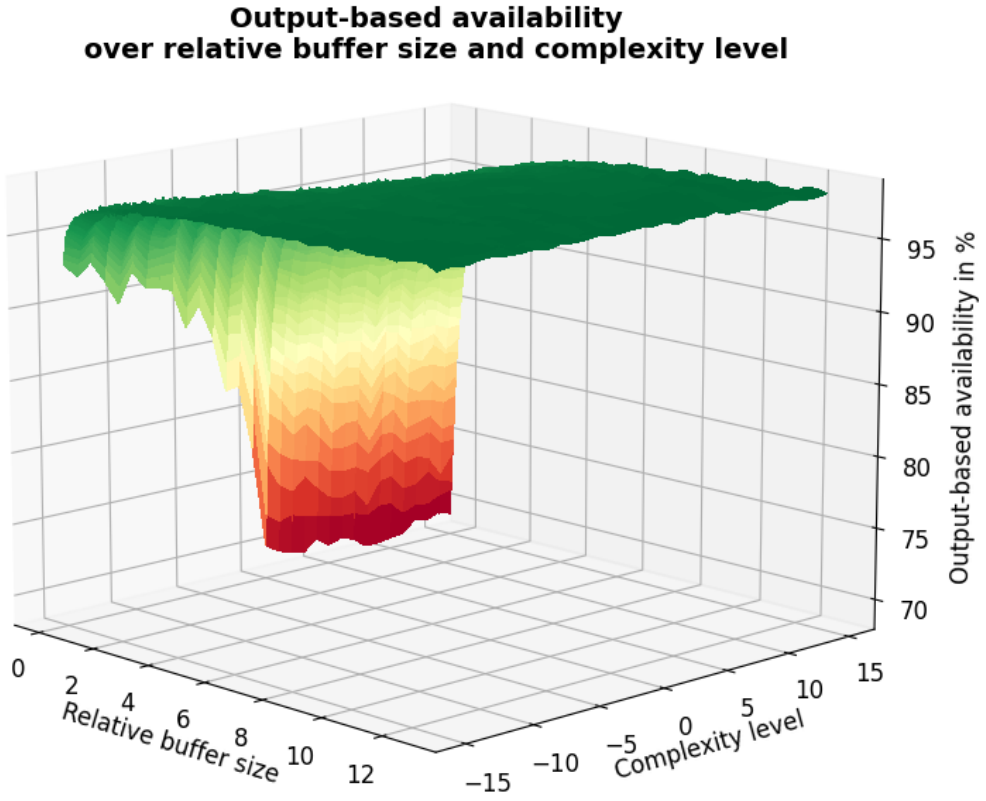




Evaluation of the performance of the two availability key figures

Event based simulation of production systems with different buffer sizes and complexity levels





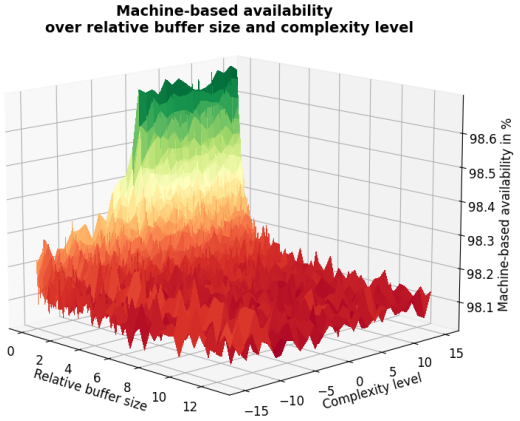
Z-AXIS NOT TO SCALE!

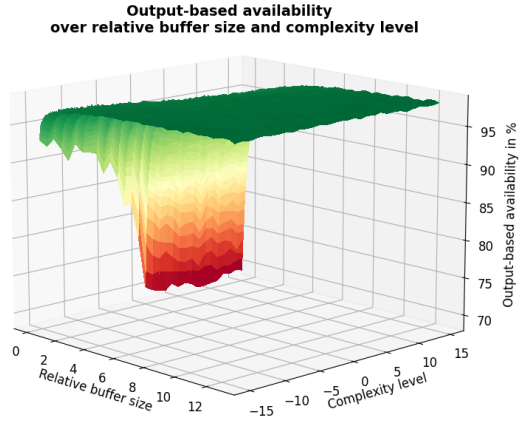
Discussion of the performance of the two key indicators

Output-based availability the more accurate key figure, but hard to record in real production system

Simulation

- Higher machine-based availability with lower buffer sizes can be explained by the simulation setup. If a machine was not working (empty buffer), it could not fail. Therefore no failure time was accumulated.
- Large differences between the two key figures especially with smaller buffer sizes and more complex systems
- Output-based availability relevant for those production systems
- Validating the results in a real production environment confirmed the trend of the results but showed, that an output-based availability is much harder to record
  - Only the maintenance relevant output losses were to be included. Therefor for each production loss it needed to be investigated, if it was maintenance related or not





Recommendations

- Output-based availability is more relevant in complex production systems with lower buffer sizes
- Recording it is difficult without further data
- Therefore output-based availability should play an important role for planning and optimization, without further research not for live performance measurement

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