

Match all things Python:

Advanced parsing of structured data using Python's new match statement

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Speaker Introduction

- **Marc-André Lemburg**
 - Python since 1994
 - Studied Mathematics
 - CEO eGenix.com GmbH
 - **Senior Solution Architect, Consulting CTO and Coach**
 - **EuroPython Society Fellow** and former Chair
 - **Python Software Foundation Fellow** and former director
 - **Python Core Developer** (PEP 100, DB-API, platform module, ...)
 - **Co-founder Python Meeting Düsseldorf**
 - Based in Düsseldorf, Germany
 - More details: <http://malemburg.com>



Intro: Recap of the new Python match statement

```
match obj:
    case list() as list_obj:
        print (f'found list: {list_obj!r}')

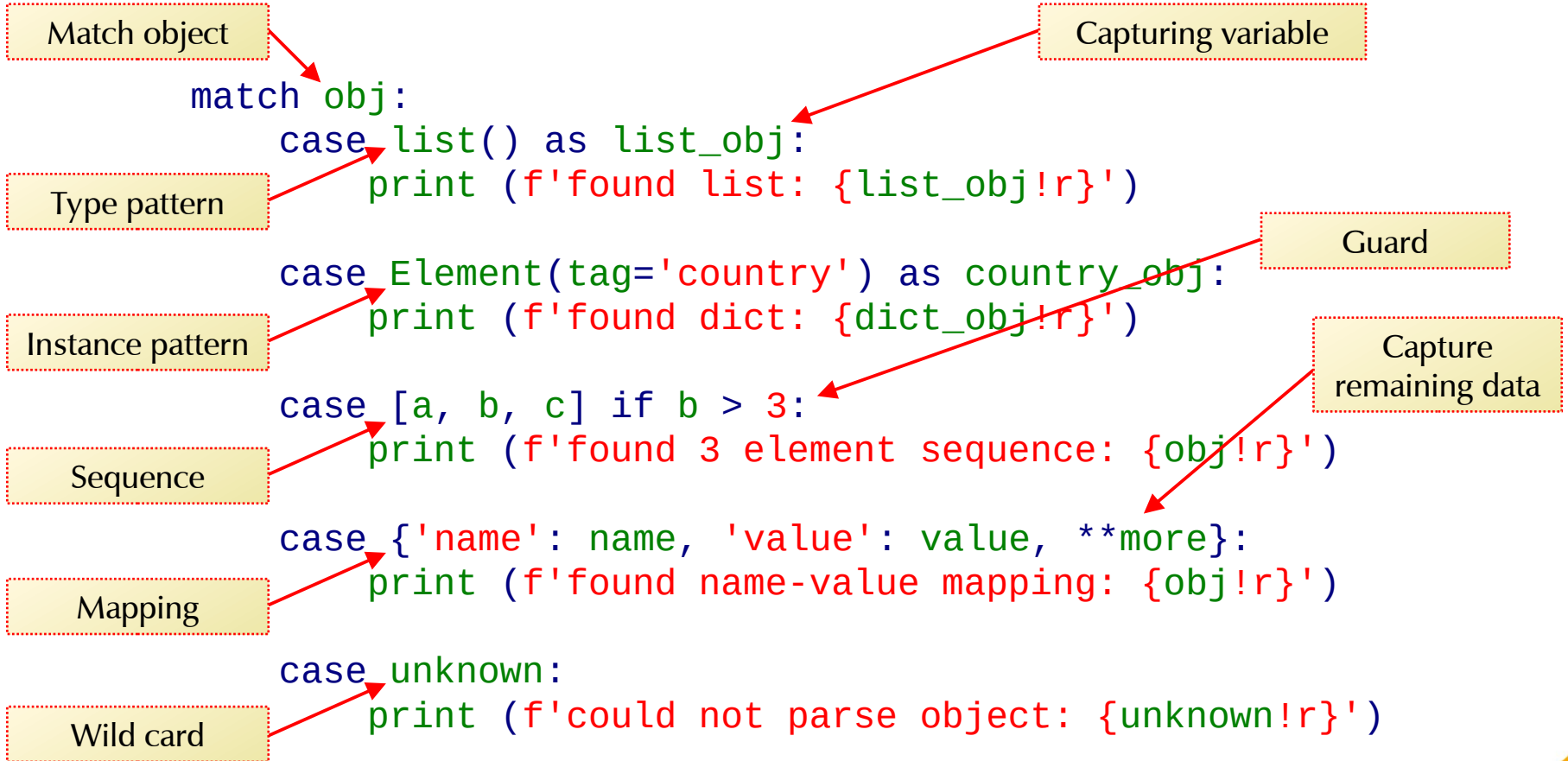
    case Element(tag='country') as country_obj:
        print (f'found dict: {dict_obj!r}')

    case [a, b, c] if b > 3:
        print (f'found 3 element sequence: {obj!r}')

    case {'name': name, 'value': value, **more}:
        print (f'found name-value mapping: {obj!r}')

    case unknown:
        print (f'could not parse object: {unknown!r}')
```

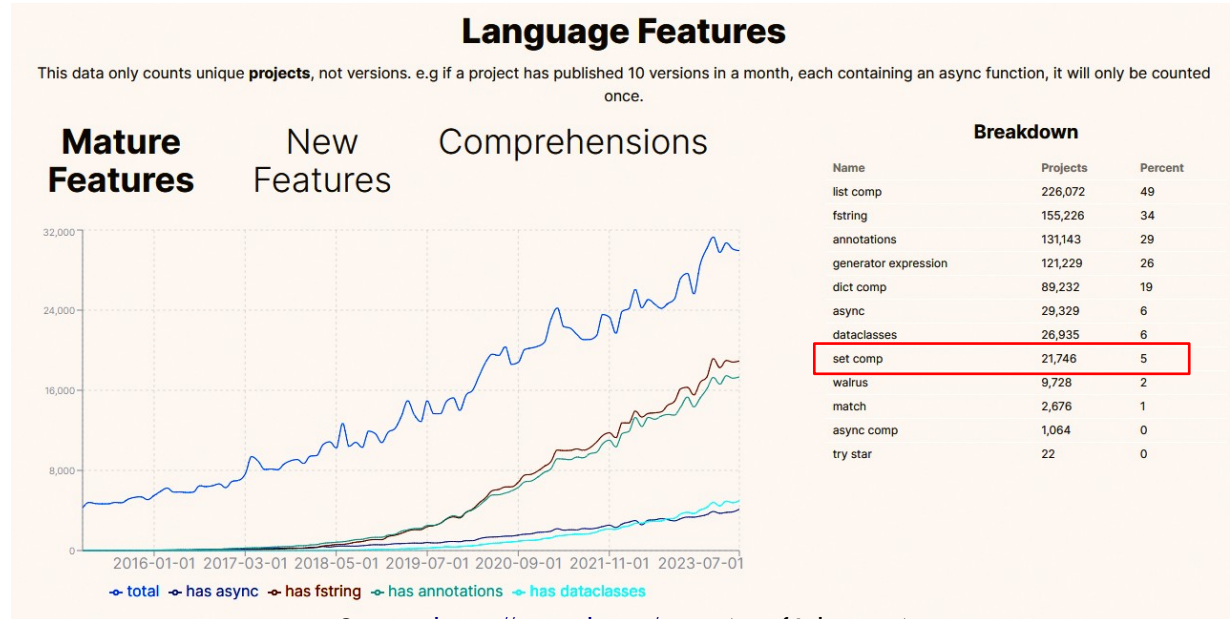
Intro: Recap of the new Python match statement



Match statement: Popularity

- Introduced in Python 3.10 (2021)
- How popular is this new feature ?

- Only 2,676 PyPI packages use the match statement
- That's about **0.55% of all packages on PyPI**



Source: <https://py-code.org/stats> (as of July 2023)

Match statement: Documentation

- PEPs
 - PEP 635 – Structural Pattern Matching: Motivation and Rationale
 - Discussion about syntax – not a good intro
 - PEP 636 – Structural Pattern Matching: Tutorial
 - Best way to start to learn the new syntax
 - PEP 634 – Structural Pattern Matching: Specification
 - In-depth spec for how things work
- Python documentation: match statement
 - Not much different than the PEPs :-(

Some techniques used in advanced parsing

- OR parsing:

```
case ["yes" | "y" | "on" | "true" | "1"] as option:
```
- Parsing optional / remaining arguments:

```
case [1, 2, *args]:  
case [1, _, _, 4]:  
case {'name':name, **more}:
```
- Instance parsing:

```
case Element(tag='country', attrib={'name': name}):
```
- Mixing local variables and capturing variables:

```
case Call(func=Name(id='isinstance'),  
          args=[Name(id=params.varname),  
                Name(id=typename)]):
```

more...
see Raymond Hettinger's
PyCon Italia 2022 talk

Keeping backwards compatibility

- *match* code will cause a **SyntaxError in Python 3.9 and lower**
- Can be emulated using *if*-constructs

- **Solution:**
 - Put new code into separate module
 - Use try-import to switch between implementations

or: Require Python 3.10+

```
match obj:
    case list() as list_obj:
        print (f'found list: {list_obj!r}')

    case Element(tag='country') as country_obj:
        print (f'found dict: {dict_obj!r}')

    case [a, b, c] if b > 3:
        print (f'found 3 element sequence: {obj!r}')

    case {'name': name, 'value': value, **more}:
        print (f'found name-value mapping: {obj!r}')

    case unknown:
        print (f'could not parse object: {unknown!r}')
```


Examples parsing structured data

- **JSON**
 - Record lists (tabular data exports)
 - GeoJSON (used for geospatial data)
- **XML**
 - Country data
- **AST**
 - *if*-statement to *match*-statement refactoring



Parsing JSON: Tabular data

- Schema:

```
schema = {  
    "type": "object",  
    "properties": {  
        "price": {"type": "number"},  
        "name": {"type": "string"},  
    },  
}
```

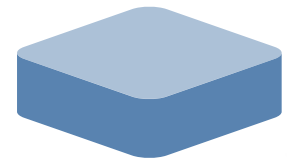
name	price	color
eggs	2.99	
eggs	2	
eggs		
eggs	3.99	brown

- Examples:

```
data_1 = {  
    "name": "eggs",  
    "price": 2.99  
}  
data_1a = {  
    "name": "eggs",  
    "price": 2  
}
```

```
data_2 = {  
    "name": "eggs"  
}  
data_3 = {  
    "name": "eggs",  
    "price": 3.99,  
    "color": "brown"  
}
```

```
table = list(data_1, data_1a, data_2, data_3)
```

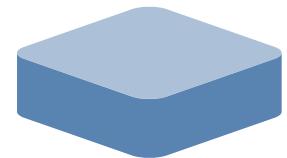


Parsing JSON: Code

- Parse one record:

```
def parse_demo_data(instance):  
    match instance:  
        case dict() as data_item:  
            match data_item:  
                case {  
                    'name': str() as name,  
                    'price': int(price) | float(price),  
                    **extra}:  
                    if extra:  
                        print (f'found extra values: {extra!r}')  
                        # Process data  
                        print (f'{name}: {price}')  
                case wrong_values:  
                    print (f'could not parse properties: {wrong_values!r}')  
            case wrong_values:  
                print (f'could not parse instance: {wrong_values!r}')
```

```
schema = {  
    "type" : "object",  
    "properties" : {  
        "price" : {"type" : "number"},  
        "name" : {"type" : "string"},  
    },  
}
```

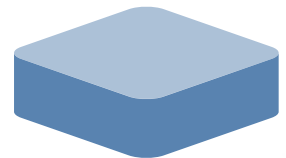


Parsing JSON: Code

- Parse multiple records:

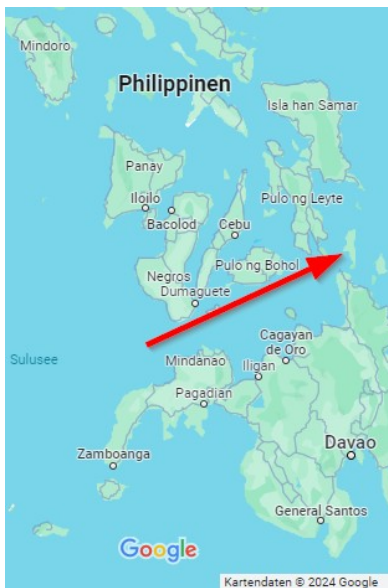
```
def parse_list_data(many_instances):  
    match many_instances:  
        case list() as data_list:  
            for instance in data_list:  
                parse_demo_data(instance)  
        case wrong_data:  
            print(f'unknown data format: {wrong_data!r}')
```

```
table = [ {'name': 'eggs', 'price': 2.99},  
          {'name': 'eggs', 'price': 2},  
          {'name': 'eggs'},  
          {'color': 'brown', 'name': 'eggs', 'price': 3.99}  
        ]
```



Parsing GeoJSON: Data

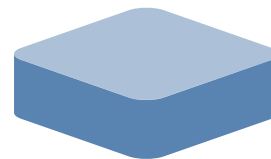
- Example:



```
# From https://geojson.org/  
GEOJSON_TYPES = (  
    'Feature',  
    'FeatureCollection',  
    'Point',  
    # more  
)
```

```
geojson_data_1 = {  
    "type": "Feature",  
    "geometry": {  
        "type": "Point",  
        "coordinates": [125.6, 10.1]  
    },  
    "properties": {  
        "name": "Dinagat Islands"  
    }  
}
```

GEOJSON

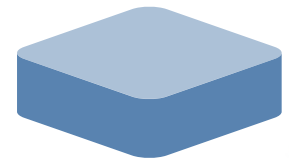


Parsing GeoJSON: Code

- Parse a GeoJSON record:

```
def parse_geojson_data(instance):
    match instance:
        case {'type': obj_type, **other_members} as obj:
            print (f'new object of type {obj_type!r}')
            if obj_type not in GEOJSON_TYPES:
                print (f'this type is not a valid GeoJSON type')
                return None
            for obj_member in other_members.items():
                match obj_member:
                    case ('geometry', geometry):
                        print (ffound geometry {geometry!r}')
                    case ('properties', properties):
                        print (ffound properties {properties!r}')
                    case wrong_member:
                        print (f'could not parse member: {wrong_member!r}')
        case wrong_values:
            print (f'could not parse object: {wrong_values!r}')
```

```
geojson_data_1 = {
    "type": "Feature",
    "geometry": {
        "type": "Point",
        "coordinates": [125.6, 10.1]
    },
    "properties": {
        "name": "Dinagat Islands"
    }
}
```

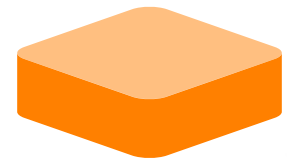


Parsing XML: Data

- Example:

```
<?xml version="1.0"?>
<data>
  <country name="Liechtenstein">
    <rank>1</rank>
    <year>2008</year>
    <gdppc>141100</gdppc>
    <neighbor name="Austria" direction="E"/>
    <neighbor name="Switzerland" direction="W"/>
  </country>
  <country name="Singapore">
    <rank>4</rank>
    <year>2011</year>
    <gdppc>59900</gdppc>
    <neighbor name="Malaysia" direction="N"/>
  </country>
```

```
<country name="Panama">
  <rank>68</rank>
  <year>2011</year>
  <gdppc>13600</gdppc>
  <neighbor name="Costa Rica" direction="W"/>
  <neighbor name="Colombia" direction="E"/>
</country>
</data>
```



From <https://docs.python.org/3/library/xml.etree.elementtree.html>

Parsing XML: Code

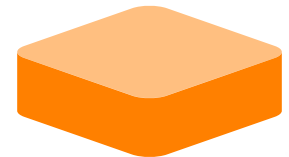
- Parse countries:

```
def parse_countries_1(tree):
    countries = {}
    for child in tree:
        match child:
            case Element(tag='country',
                          attrib={'name': name}) as country:
                for child in country:
                    neighbors = {}
                    match child:
                        case Element(tag='rank', text=rank):
                            rank = int(rank)
                        case Element(tag='year', text=year):
                            year = int(year)
                        case Element(tag='gdppc', text=gdppc):
                            gdppc = float(gdppc)
                        case Element(
                            tag='neighbor',
                            attrib={'name': nb_name,
                                    'direction': nb_direction}):
                            neighbors[nb_name] = nb_direction
```

```
<country name="Panama">
  <rank>68</rank>
  <year>2011</year>
  <gdppc>13600</gdppc>
  <neighbor name="Costa Rica" direction="W"/>
  <neighbor name="Colombia" direction="E"/>
</country>
```

```
        case wrong_data:
            raise TypeError(
                error_string(wrong_data,
                             'country element'))
        countries[name] = dict(
            rank=rank,
            year=year,
            gdppc=gdppc,
            neighbors=neighbors,
        )
    case wrong_data:
        raise TypeError(error_string(wrong_data,
                                     'country'))

    return countries
```



Note: This does not detect missing child elements. See repo for a version which does.

Parsing ASTs: Data

- Example function and AST:

```
def example(x):  
    if isinstance(x, int) and x > 12:  
        print ('Int > 12: {x}')    elif isinstance(x, float):  
        print ('Float: {x}')    elif isinstance(x, str) and len(x) > 5:  
        print ('String with more than 5 chars: {x}')    else:  
        print ('Unknown type: {x}')
```

- Idea:** Refactor this into an equivalent function using the *match* statement

```
Module(  
  body=[  
    FunctionDef(  
      name='example',  
      args=arguments(  
        posonlyargs=[],  
        args=[  
          arg(arg='x')],  
        kwonlyargs=[],  
        kw_defaults=[],  
        defaults=[]),  
      body=[  
        If(  
          test=BoolOp(  
            op=And(),  
            values=[  
              Call(  
                func=Name(id='isinstance', ctx=Load()),  
                args=[  
                  Name(id='x', ctx=Load()),  
                  Name(id='int', ctx=Load()),  
                ],  
                keywords=[],  
              ),  
              Compare(  
                left=Name(id='x', ctx=Load()),  
                ops=[  
                  Gt(),  
                ],  
                comparators=[  
                  Constant(value=12)],  
                ],  
              ),  
            ],  
          ),  
          body=[  
            Expr(  
              value=Call(  
                func=Name(id='print', ctx=Load()),  
                args=[  
                  Constant(value='Int > 12: {x}')],  
                keywords=[],  
              ),  
            ],  
          ),  
        ],  
      ),  
    ],  
  ),  
  ... lots more
```



Parsing ASTs: Code

- Parse function AST & refactor:

```
def if_match_refactor(fct):
    source = inspect.getsource(fct)
    tree = ast.parse(source) # AST.Module
    # Find functions
    for node in tree.body:
        match node:
            case FunctionDef(
                name,
                args=arguments(args=[arg(arg=varname)])):
                # Refactor function name with variable varname
                function_refactor(node, name, varname)
            case _:
                # skip
                pass
    return tree
```

```
def function_refactor(fct_node, name, varname):
    # Find if-elif-else
    new_body = []
    for node in fct_node.body:
        match node:
            case If(test, body, orelse):
                # Scan for match cases written as if-elif chain
                cases, orelse = scan_if(node, varname,
                                         test, body, orelse)
                if cases:
                    # Refactor to use match instead
                    node = if_refactor(node, varname,
                                         cases, orelse)
            case _:
                # Not an if node
                break
    new_body.append(node)
    fct_node.body = new_body
```



Parsing ASTs: Code

- Scan *if-elif-else* chains recursively:

```
def scan_if(node, varname, test, body, orelse, cases=None):
    # Trick for non-capturing vars
    class params:
        pass
    params.varname = varname
    # Check for possible match refactoring if-candidate
    match test:
        case Call(func=Name(id='isinstance'),
                  args=[Name(id=params.varname),
                        Name(id=typename)]):
            # isinstance(varname, typename)
            new_case = (varname, typename, None, body)
        case BoolOp(op=And(),
                    values=[
                        Call(func=Name(id='isinstance'),
                            args=[Name(id=params.varname),
                                    Name(id=typename)]),
                        condition
                    ]):
            # isinstance(varname, typename) and condition
            new_case = (varname, typename, condition, body)
```

```
case _:
    # Unsupported if-variant
    return cases, node
# Add new case
if cases is None:
    cases = []
cases.append(new_case)
# Recursively check whether there are more if-elif cases
match orelse:
    case [If(elif_test, elif_body, elif_orelse) as elif_node]:
        cases, orelse = scan_if(
            elif_node, varname,
            elif_test, elif_body, elif_orelse,
            cases)
    case _:
        pass
return cases, orelse
```



Parsing ASTs: Code

- Refactor *if-elif-else* into *match* statements:

```
def if_refactor(if_node, varname, cases, orelse):
    # Build match_cases
    case_nodes = []
    match_case(
        pattern=MatchClass(
            cls=Name(id=typename),
            patterns=[],
            kwd_attrs=[],
            kwd_patterns=[]),
        guard=condition,
        body=body)
    for (varname, typename, condition, body) in cases
    ]
    case_nodes.append(
        match_case(
            pattern=MatchAs(),
            body=orelse)
    )
```

```
# Build Match node
match_node = Match(
    subject=Name(id=varname),
    cases=case_nodes,
)
return match_node
```



Parsing ASTs: Fully automatic refactoring


- Example:

```
def example(x):  
    if isinstance(x, int) and x > 12:  
        print ('Int > 12: {x}')    elif isinstance(x, float):  
        print ('Float: {x}')    elif isinstance(x, str) and len(x) > 5:  
        print ('String with more than 5 chars: {x}')    else:  
        print ('Unknown type: {x}')
```

```
def example(x):  
    match x:  
        case int() if x > 12:  
            print('Int > 12: {x}')        case float():  
            print('Float: {x}')        case str() if len(x) > 5:  
            print('String with more than 5 chars: {x}')        case _:  
            print('Unknown type: {x}')
```



What about performance ?

Name	Match Variant	If Variant	Notes
Int	111	52	
Int capvars	116 (generic) 548 (inlined)	56	<i>Avoid inlined capvars (?)</i>
List ints	61	82	
Str	102	54	
Int guards	143	49	
Complex obj with capvars	663 (generic) 3410 (inlined)	306	<i>Avoid inlined capvars (?)</i>
Float or int	104	62	

Using Python 3.11. All numbers refer to nanoseconds. See repo for benchmark details

Performance Bug with Captured Variables ?

Name	Match Variant	If Variant	Notes
Int	111	52	
Int capvars	116 (generic) 548 (inlined)	56	<i>Avoid inlined capvars (?)</i>
List ints	61	82	<i>Generic: case <code>int()</code> as <code>a</code>: Inlined: case <code>int(a)</code>:</i>
Str	102	54	
Int guards	143	49	
Complex obj with capvars	663 (generic) 3410 (inlined)	306	<i>Avoid inlined capvars (?)</i>
Float or int	104	62	

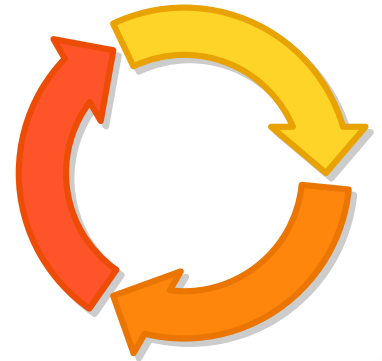
Using Python 3.11. All numbers refer to nanoseconds. See repo for benchmark details

Benchmarking: Conclusions

- *match* is **about 2 times slower** than *if* in most cases
- *match* **shines** for sequence matching

```
match obj:  
    case [a, b, c]:  
        do_something()
```

- Python 3.10 – 3.12: still first implementation of the PEPs
 - No significant optimizations have been applied since
 - Some parts appear to have performance bugs (inlined capvars)



Overall conclusion: Advanced parsing with *match*

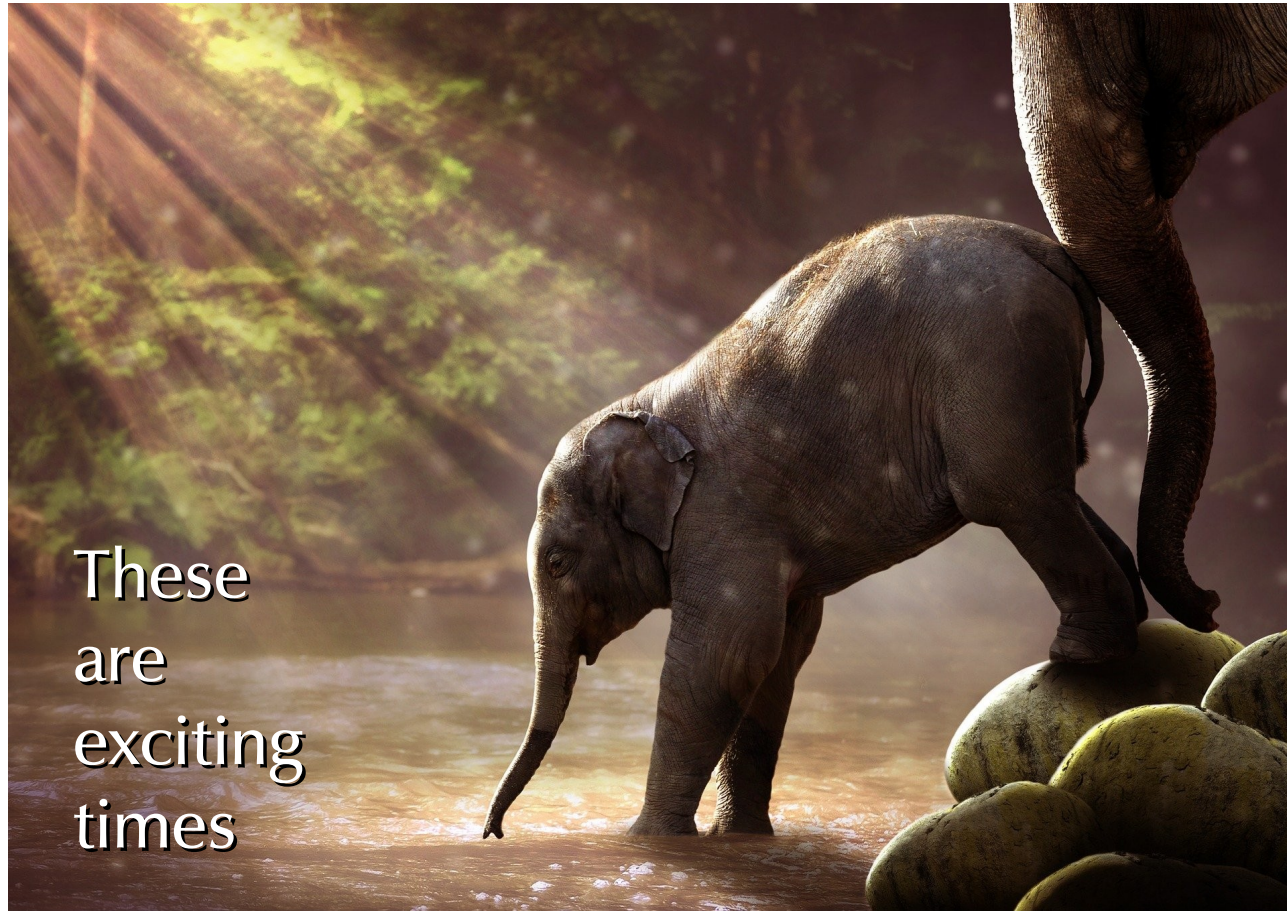
- *match* isn't fast (yet)
 - Lot's of room for improvements
- *match* is great for complex parsing tasks where readability counts:

```
if isinstance(obj, int) and obj > 20:
    value = obj
elif (isinstance(obj[0], int) and
      isinstance(obj[1], int) and
      isinstance(obj[2], dict) and
      ('abc' in obj[2]) and
      isinstance(obj[2]['abc'], int) and
      isinstance(obj[3], tuple) and
      isinstance(obj[3][0], int) and
      isinstance(obj[3][1], int) and
      isinstance(obj[3][2], int)):
    [a, b, q1, (d, e, f)] = obj
    c = q1['abc']
else:
    pass
```

```
match obj:
    case int() as value if value > 20:
        pass
    case [int() as a, int() as b,
          {'abc': int() as c},
          (int() as d, int() as e, int() as f)]:
        pass
    case _:
        pass
```



Main takeaway: Never stop **learning** and **trying out new things**



These
are
exciting
times

Thank you for your attention !



Time for discussion

Contact

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References

- Some content taken from:
 - <https://py-code.org/stats>
 - https://de.wikipedia.org/wiki/Tango_Desktop_Project
- Several photos taken from Pixabay and Unsplash
- Some screenshots taken from the mentioned websites
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