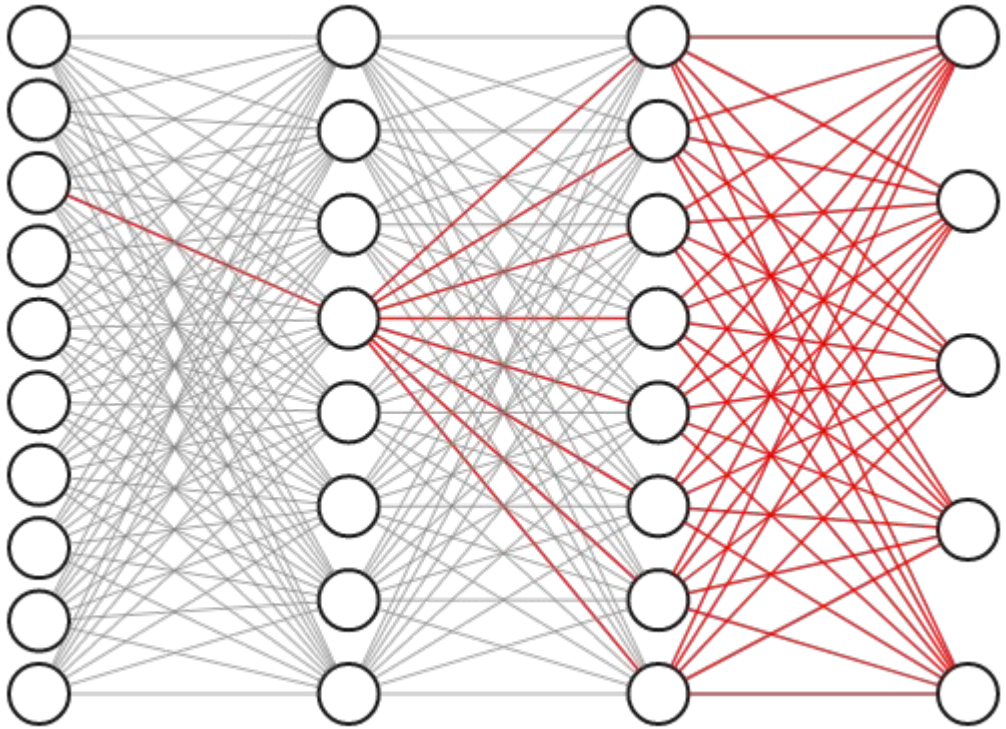
RIT

GNP: Fast and Scalable Tensor Engine

Viet Nguyen

Overview



- GNP (GPU Numpy) is a **fast** and **scalable** tensor computing library that utilize the **parallel computation** of GPUs.
- Built upon numpy library.
- GNP boost the performance by **optimizing computation** of numpy ndarray on GPU.

Requirement

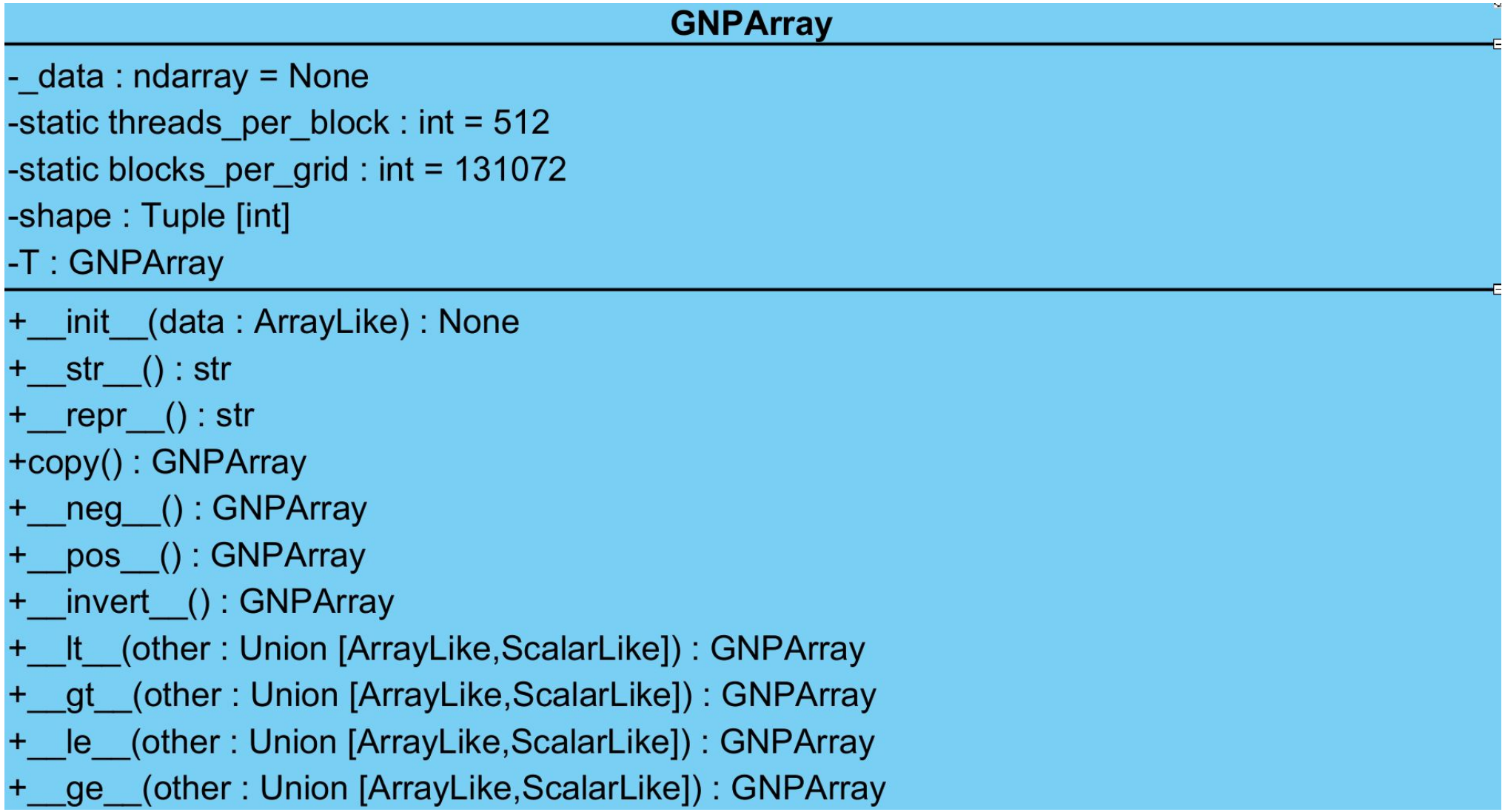
- Numba: just-in-time compiler
- Cuda kernel can be implemented in python using numba's cuda decorator

```python
import numpy as np
import numba
from numba import cuda

@cuda.jit
def increment_by_one(an_array):
    # Thread id in a 1D block
    tx = cuda.threadIdx.x
    # Block id in a 1D grid
    ty = cuda.blockIdx.x
    # Block width, i.e. number of threads per block
    bw = cuda.blockDim.x
    # Compute flattened index inside the array
    pos = tx + ty * bw
    if pos < an_array.size:  # Check array boundaries
        an_array[pos] += 1

an_array = np.asarray([1,2,3])

threadsperblock = 32
blockspergrid = (an_array.size + (threadsperblock - 1)) // threadsperblock
a = increment_by_one[blockspergrid, threadsperblock](an_array)
an_array

# (2, 3, 4)
```

GNP: supported functions

- Unary operators:
  - Negation
  - Positive Assignment
  - Invert
- Binary operators:
  - Add
  - Subtract
  - Multiply
  - True divide
  - Floor divide
  - Mod
  - Pow
  - And
- Binary operators:
  - Or
  - Xor
  - Right shift
  - Left shift
- Comparison operators:
  - Greater than
  - Less than
  - Greater than or equal to
  - Less than or equal to
  - Equal
  - Not equal
- Linear Algebra:
  - Matrix multiplication
  - Batch matrix multiplication
- (Experimental) High level APIs:
  - Neural network sequential API
  - Fully connected neural network forward and backward pass
  - SGD Optimizer, MSE Loss
  - Non-linear activations: Relu, Tanh, Sigmoid

The GNP Array class: structure



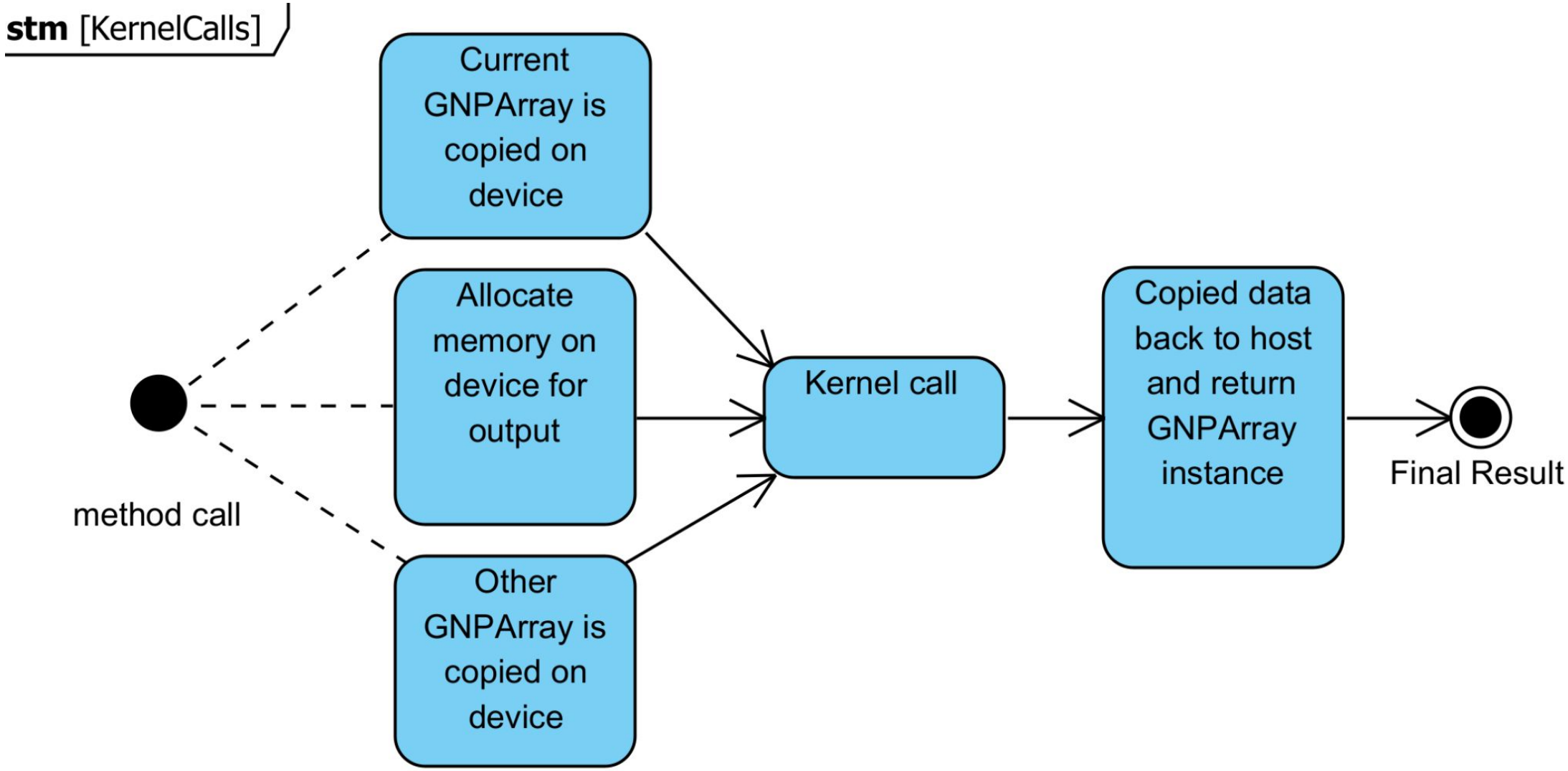
The GNP Array class: structure

+__eq__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__ne__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__add__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__sub__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__mul__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__truediv__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__floordiv__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__mod__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__pow__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__rshift__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__lshift__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__and__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__or__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__xor__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__isub__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__iadd__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__imul__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__idiv__(other : Union [ArrayLike,ScalarLike]) : GNPArray

The GNP Array class: structure

```
+__lshift__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__and__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__or__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__xor__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__isub__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__iadd__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__imul__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__idiv__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__ifloordiv__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__imod__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__ipow__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__ilshift__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__irshift__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__iand__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__ior__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__ixor__(other : Union [ArrayLike,ScalarLike]) : GNPArray
+__matmul__(other : Union [ArrayLike,ScalarLike]) : GNPArray
```

The GNP Array class: kernel calls

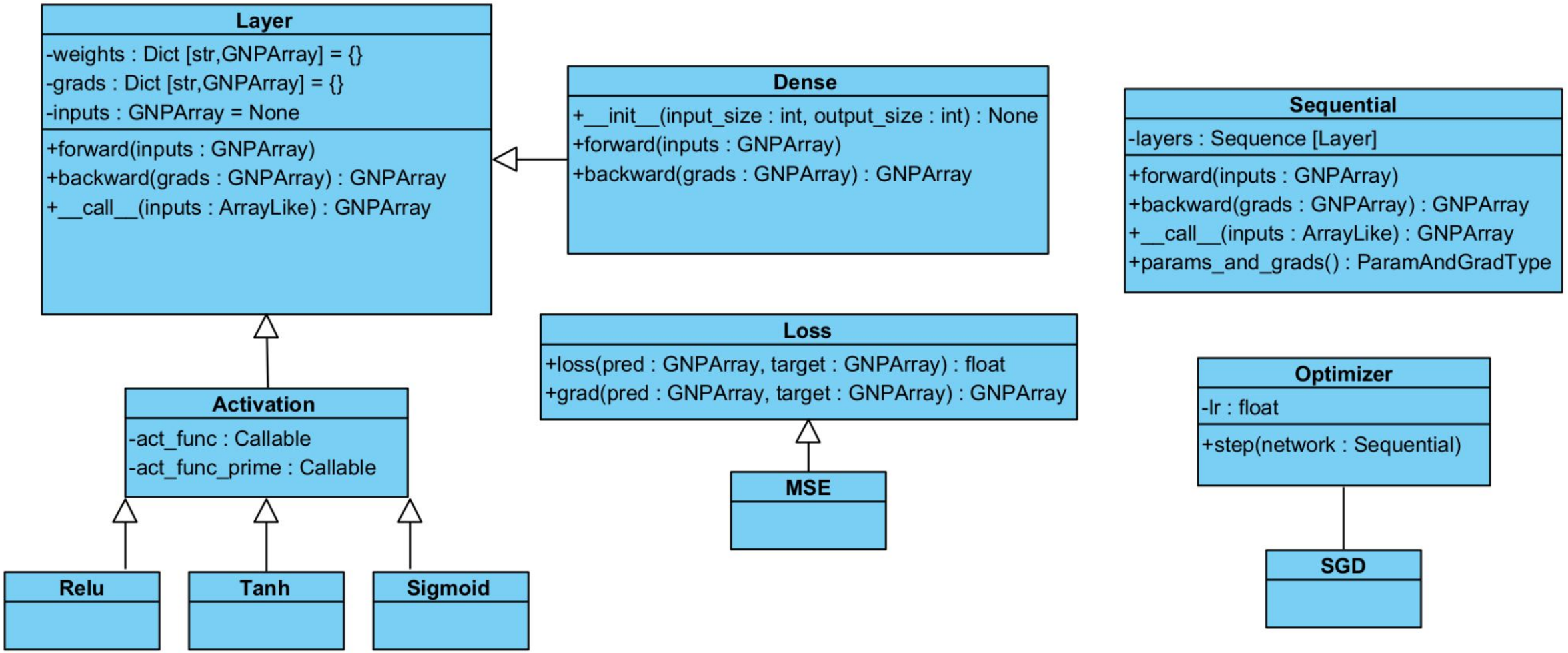


The GNP Array class: Example

Let's test GNPArray

- `gnparray_test.py`
- `time_testing.py`: For batch matrix multiplication of two tensor shape (600, 600, 600)
  - Time for GNP computation: ~2.482605218887329 seconds
  - Time for Numpy computation: ~4.490365982055664 seconds
  - Time for numpy computation is often unstable

The GNP neural network APIs (experimental)



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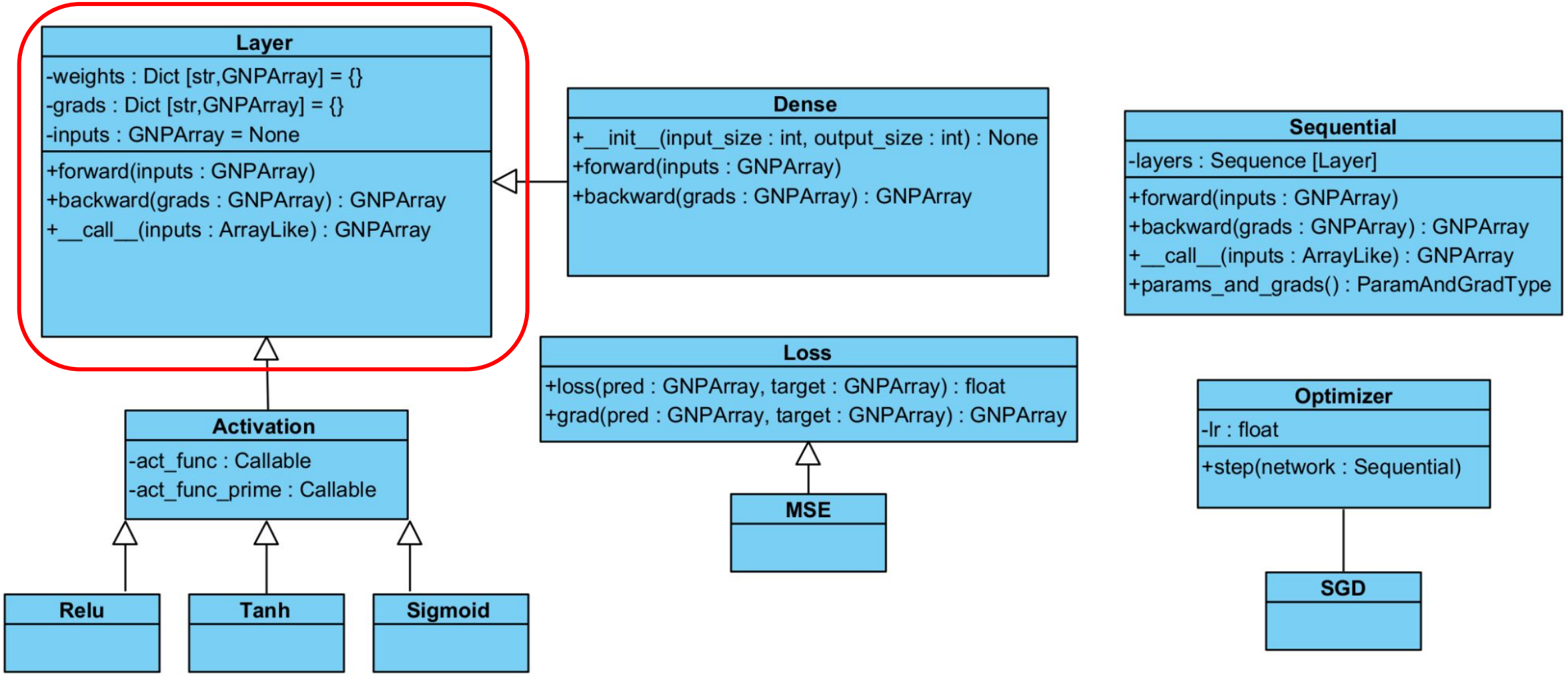

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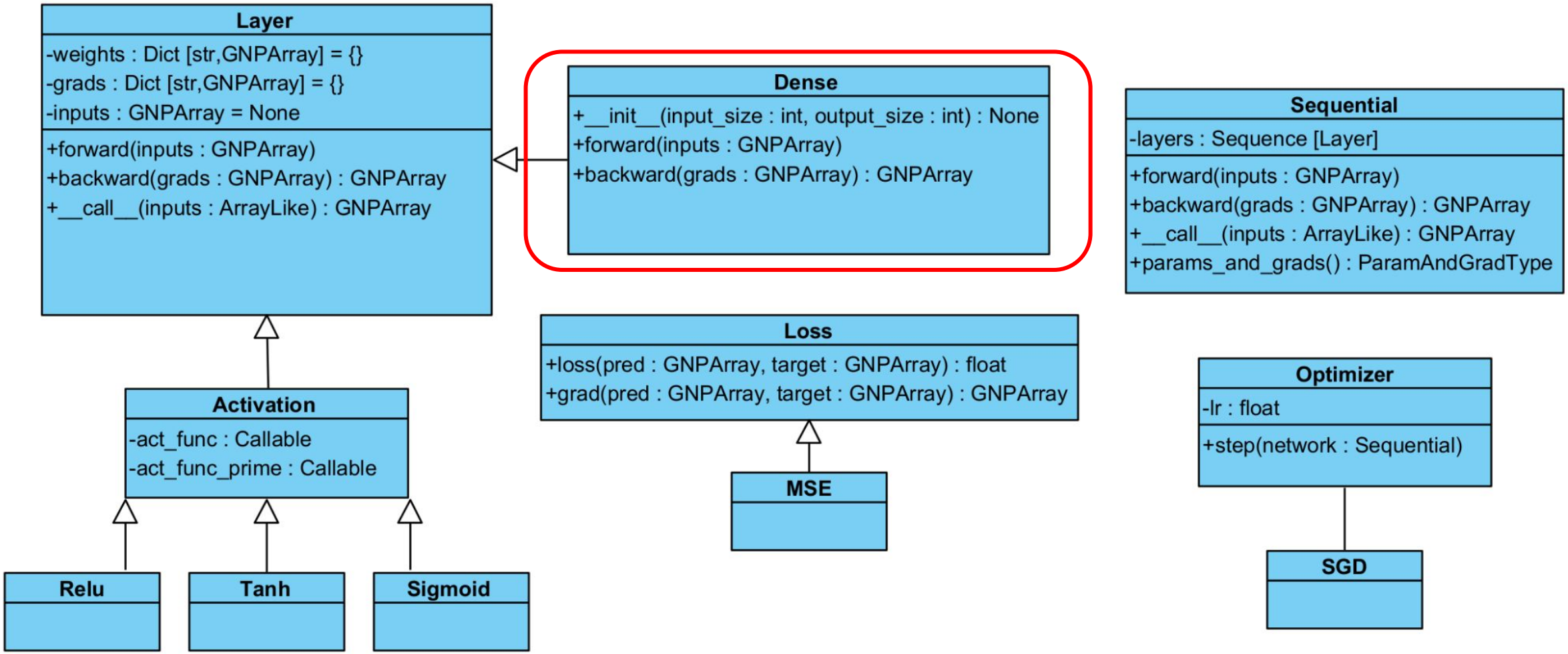

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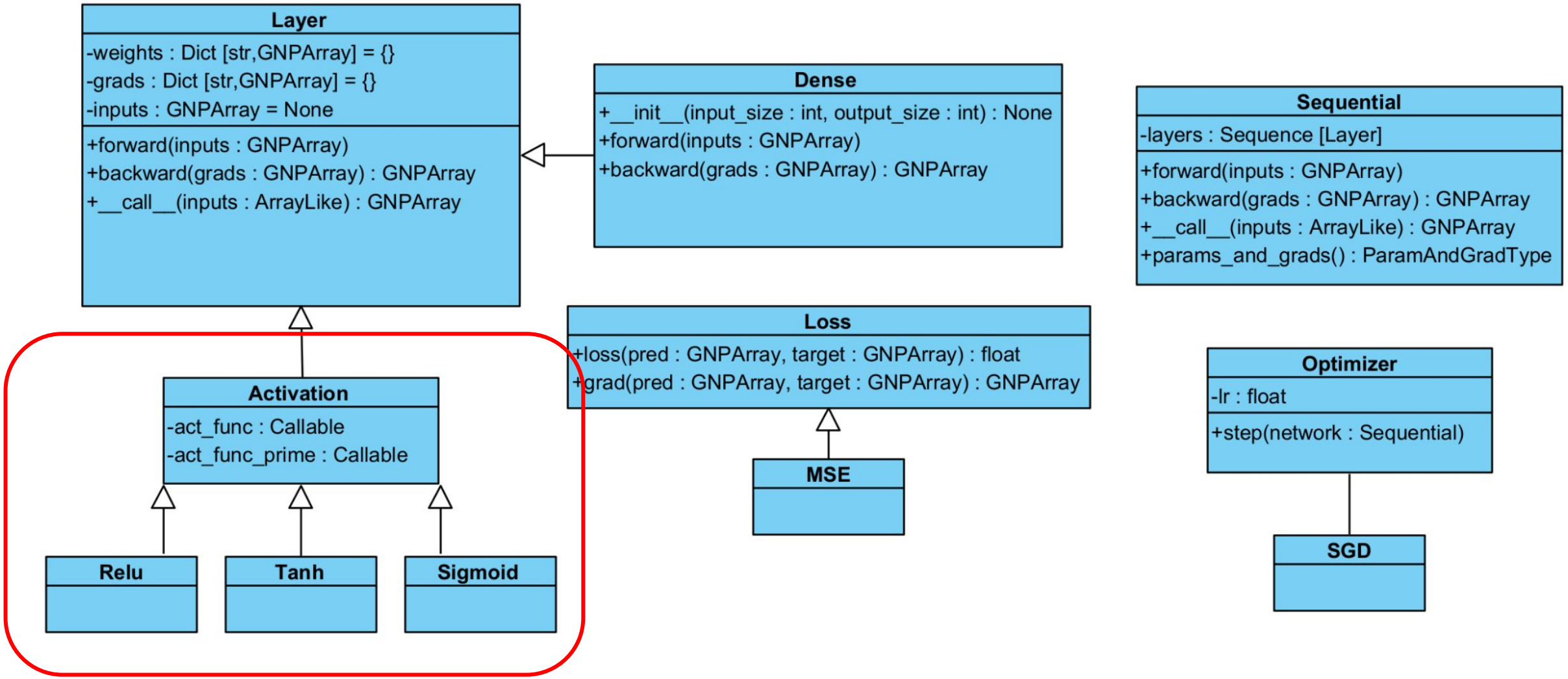

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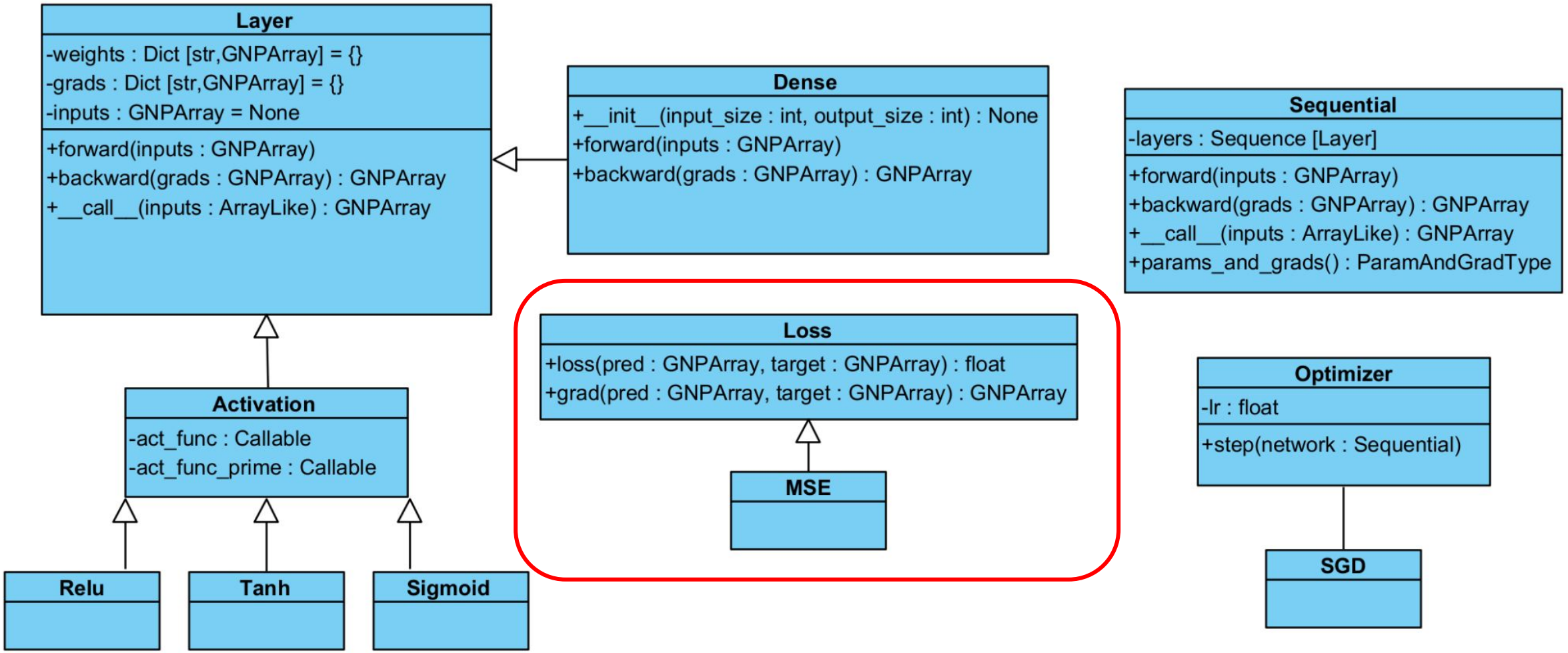

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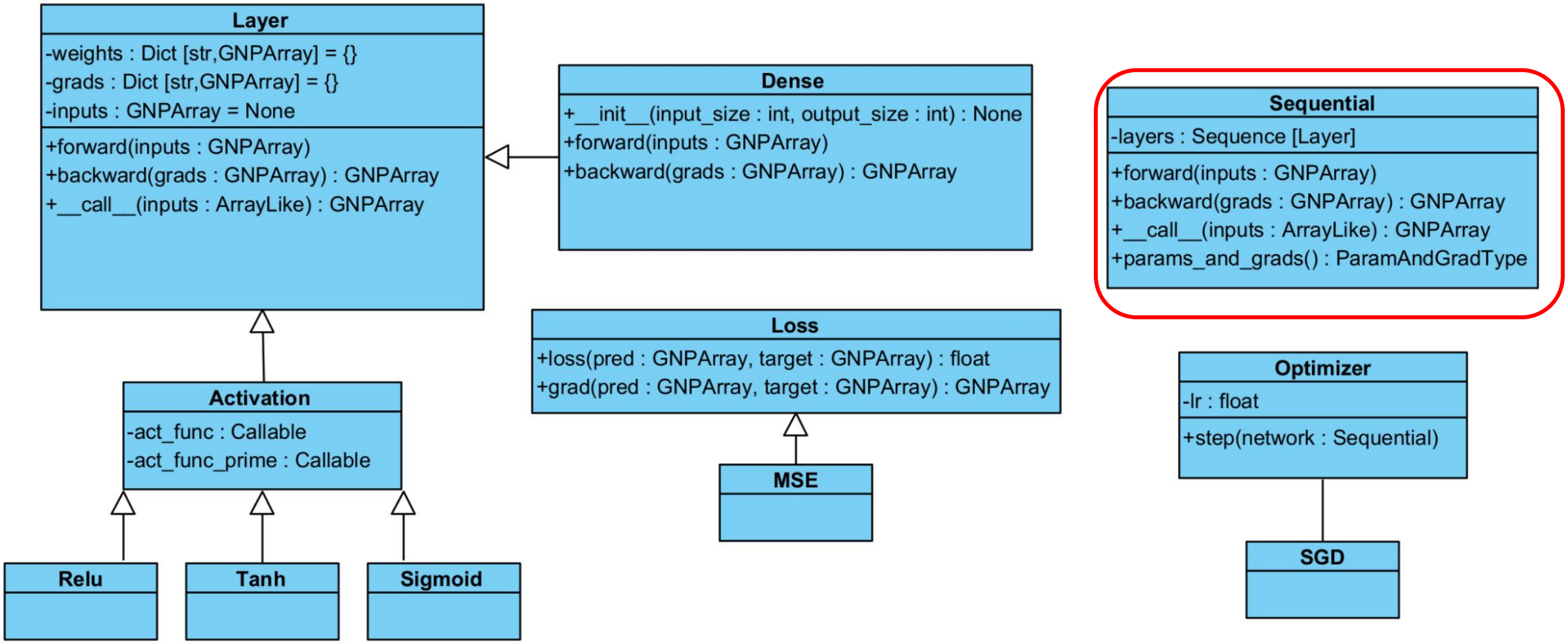

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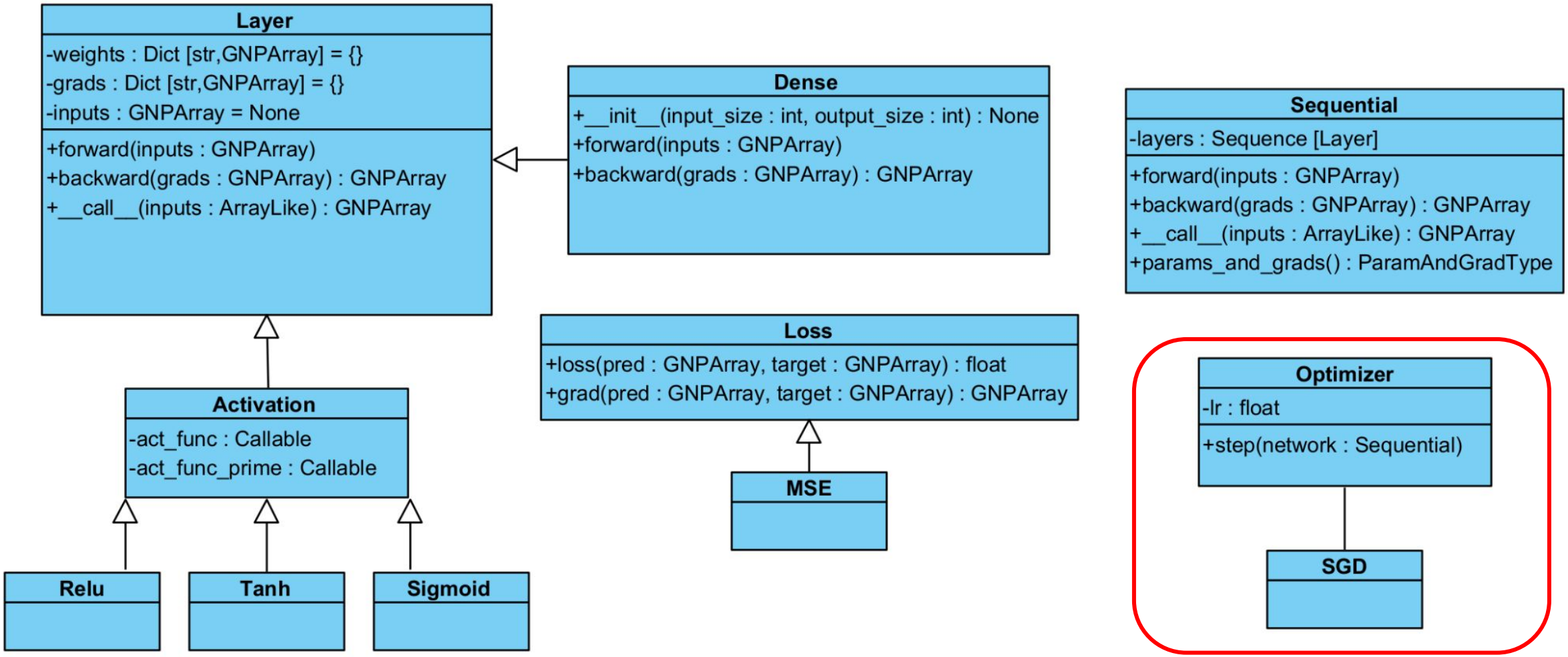

Future Work

- Efficient Array Operators and more functions
- More function in the neural network APIs:
  - Loss functions: BCE, NLL, etc.
  - Non-linear activation functions: Swish, Softmax, etc.
  - Layer types: CNN, LSTM, etc.
- More testing should be done
- Probability/Distribution APIs

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Thank you for listening